APPENDIX A
BASELINE RISK ASSESSMENT
WEST LAKE LANDFILL
OPERABLE UNIT 1

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EXECUTIVE SUMMARY

A Baseline Risk Assessment (BRA) for Operable Unit 1 of the West Lake Landfill superfund site has been prepared by Auxier & Associates in coordination with Engineering Management Support, Inc. (EMSI) on behalf of the Operable Unit1 respondents. This assessment was developed in accordance with EPA's guidance for human health and ecological risk assessments (EPA 1989).

Contamination at Operable Unit 1 of the West Lake Landfill consists of two localized areas within the landfill property (designated as Areas 1 and 2), and one small portion of an adjacent lot outside the landfill, formerly owned by Ford Motor Credit Company (designated as the Ford property in this assessment) and now known as Crossroad Lot 2A2 and the buffer zone. Data characterizing these areas have been evaluated to identify those analytes considered to be constituents of potential concern (COPCs) to be quantitatively evaluated in the risk assessment. Radiological COPCs selected for Area 1, Area 2, and the Ford property were determined to be uranium-238, uranium-235, thorium-232, and their associated decay products. Nonradiological COPCs selected for Area 1 were arsenic and aroclor-1254. Nonradiological COPCs selected for Area 2 were arsenic, lead, uranium and aroclor-1254. No nonradiological COPCs were identified for the Ford property because all nonradiological analytes detected were below risk-based screening levels.

Hypothetical receptor scenarios were selected for risk characterization, based upon an assessment of the characterization data describing the source term, existing access controls, and the current and projected future land uses. The potential for health effects from exposure to site-related contaminants was estimated for potential current and possible future receptors located onsite and in offsite areas potentially affected by Operable Unit 1.

Potential receptors included a landfill grounds keeper working adjacent to Areas 1 and 2 (current), an onsite grounds keeper working on Areas 1 and 2 (future), and an offsite (buffer zone or Crossroad property) grounds keeper (both current and future). Because maintenance activities are not currently being conducted in Areas 1 and 2, external radiation exposure is the only potential exposure pathway for a grounds keeper in other areas of the landfill. Therefore, only this pathway was evaluated under the current exposure scenario.

Additional future exposure scenarios evaluated in the BRA included a hypothetical user of a building adjacent to Areas 1 or 2, who uses Areas 1 or 2 either for parking or for open storage (future). Residential receptors on the landfill, commercial building users, and construction workers on Areas 1 and 2 were not evaluated due to the predominantly commercial/industrial nature of land use in this area and the existing deed restrictions that restrict current and future land uses of Areas 1 and 2 and the landfill.

The physical characteristics of the site and postulated receptor behavior were used to identify potential exposure pathways to these hypothetical receptors. The potential exposure routes identified for evaluation in the risk assessment included exposure to external radiation, inhalation of dust and gas, dermal contact, and incidental ingestion of soil.

The carcinogenic and systemic toxicity of the various COPCs were determined as part of a toxicity assessment. This assessment provides a brief description profiling their modes of action, as well as the types and severity of their health effects. These toxicity profiles include the latest carcinogenic slope factors and chemical reference doses for each COPC as a quantitative measure of their toxicity.

Maximum credible risks were calculated for hypothetical current receptor scenarios including a grounds keeper performing maintenance activities adjacent to Areas 1 and 2 and a grounds keeper on the adjacent Ford property. The carcinogenic risks to each of these hypothetical receptors were estimated to be within the generally acceptable EPA target risk range of 10^{-6} to 10^{-4} . The dominant exposure pathway for these receptors was determined to be external radiation exposure from radionuclides in soil.

Receptor scenarios for the Ford property grounds keeper and the grounds keeper working onsite in Areas 1 and 2 were also evaluated under projected future conditions. The potential risks to future onsite and offsite receptors, represented by the grounds keeper working in Area 1, Area 2, and the Ford property, were calculated to be 6×10^{-5}, 2×10^{-4}, and 2×10^{-6}, respectively. With the possible exception of the future grounds keeper working in Area 2, the calculated risks for the future grounds keeper scenarios were within EPA's target risk range of 10^{-4} to 10^{-6}.

The evaluation of potential risks that might be posed to an individual who uses a building constructed outside of, but adjacent to, Areas 1 or 2, and who uses Areas 1 or 2 for parking, indicated that credible risks are expected to be within the generally acceptable

EPA target risk range of 10^{-6} to 10^{-4}. The potential risk to a future worker who may be involved in outdoor storage activities in Areas 1 and 2 was calculated to be 1×10^{-4} for Area 1 and 4×10^{-4} for Area 2. All of the potential risk associated with this hypothetical scenario is due to external radiation exposure.

To put the risks posed by this site in context, these incremental risks to future workers at the site for the assumed radiation exposure scenarios are less than a few percent of the lifetime risk from natural background radiation exposures of the same persons. This is because the average radiation dose received by residents of the United States from natural background radiation sources corresponds to a calculated incremental lifetime cancer risk well over 10^{-2}. For example, a person living in a brick house versus a wooden house would experience a comparable increase in lifetime radiation risk as the calculated incremental risks for future workers at this site.

Non-radiological contaminants are unlikely to cause an unacceptable risk to human health under current or future conditions for any of these onsite receptor scenarios. Adverse systemic (non-carcinogenic) health effects are not expected, as the calculated hazard indices (HIs) for non-radiological COPCs were significantly less than one.

Areas of uncertainty identified for the Operable Unit 1 risk assessment include the precise subsurface extent of the radiological materials and characterization of the radiological source term (relatively low-impact uncertainty), the behavior of the various receptors postulated (relatively low-impact uncertainty), and toxicological information for the COPCs (relatively high-impact uncertainty). The relative potential impact of these uncertainties on the results of the risk assessment and the projected direction of the bias introduced by the identified uncertainties were estimated for the risk assessment. It is judged that these biases over-estimate the potential impacts to human health from this site. For example, the characterization efforts included biased sampling designed to yield conservative estimates of the quantities and extent of radiological materials, which likely over estimate actual conditions.

The BRA included a screening level ecological assessment. There is a significant amount of uncertainty associated with quantifying the actual potential for ecological impacts. To deal with the uncertainty, a screening level ecological risk assessment uses highly conservative assumptions to estimate the potential total daily exposures for plants and

animals, and compares these estimated values to benchmark toxicity values. If an estimated dose exceeds the benchmark toxicity value, it does not mean that chemical will have an ecological impact. It does mean there could be an ecological impact, based on the stated assumptions. The conservative assumptions used in the screening level ecological assessment resulted in some HIs that are greater than 1.0. Operable Unit 1, however, currently supports vegetative and animal communities with no observable impact to the plant communities.

Moreover, the existing plant and animal communities are located within areas that are part of the landfill operations. These ecosystems are present within the landfill, as a result of the existing institutional controls, and other limitations on land use within or adjacent to Operable Unit 1, that have allowed field succession to take place. Therefore, any disturbance of the landfill such as might occur with remediation activities, may significantly alter or destroy the habitats that currently exist, forcing wildlife to migrate to other areas. The increasing industrial use of areas around the landfill has removed, and will continue to remove, significant amounts of wildlife habitat forcing some larger species to leave this area and reducing the overall ability of the area to support some types of wildlife.

A.1.0 INTRODUCTION

A.1.1 OVERVIEW

This Baseline Risk Assessment (BRA) has been prepared by Auxier & Associates, Inc. (A&A) for Engineering Management Support Inc. (EMSI) on behalf of the "Respondents" Cotter Corporation (N.S.L.), Laidlaw Waste Systems (Bridgeton), Inc., Rock Road Industries, Inc., and the United States Department of Energy. The BRA has been prepared as part of the Remedial Investigation/Feasibility Study (RI/FS) for Operable Unit 1 at the West Lake Landfill located in Bridgeton, Missouri.

Landfill activities at the West Lake Landfill began in the early 1950s or, perhaps, the late 1940s. The portion of the landfill that was filled during that time was not subject to State permitting, and is termed the "unregulated landfill". In 1974, a State landfill permit was obtained; the portion of the landfill that was filled after 1974 was subject to a permit from the Missouri Department of Natural Resources (MDNR) and hence is referred to as the "regulated landfill".

Operable Unit 1 consists of two areas of radiologically impacted materials present at the West Lake Landfill—Radiological Area 1 (Area 1) and Radiological Area 2 (Area 2). A third area with radiologically impacted soils is the adjacent off-site Ford property. These three areas are considered separately in this risk assessment and have been selected for evaluation in the Operable Unit 1 conceptual model. Other organizations are investigating other parts of the West Lake Landfill as part of Operable Unit 2.

This report has been prepared in accordance with the requirements of the Administrative Order on Consent (AOC) between the U.S. Environmental Protection Agency (EPA) and the Respondents for OU-1 at the West Lake Landfill, as amended to allow the Respondents to develop the BRA (EPA 1992a). Specifically, this report presents the information required by Section IX of the AOC.

A.1.1.1 Environmental Compliance Process

The BRA, which provides an assessment of baseline health risks and environmental impacts for a contaminated site, is an important element of the remedial investigation/feasibility study (RI/FS) process developed by EPA. This process addresses the cleanup of hazardous waste sites under

the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), as amended. Four primary evaluation documents comprise the RI/FS for the West Lake Landfill:

- RI—presents site characterization results and defines the nature and extent of contamination;
- BRA—uses information from the Site Characterization Summary Report (SCSR) to estimate human health and environmental impacts that could occur if no cleanup action was taken and includes both the baseline human health evaluation and the baseline ecological assessment;
- FS—develops and evaluates cleanup alternatives, considering the results of the BRA and the various response actions that might be appropriate;
- Proposed Plan (PP) —summarizes the analysis of final alternatives from the FS and identifies the preferred remedial action alternative. EPA will prepare the PP.

These four documents will be used to develop the Record of Decision (ROD) for the West Lake Landfill.

The SCSR (EMSI 1997a) was originally intended as a summary document to assist EPA in the preparation of a BRA. The SCSR presents the results of the various site characterization activities for OU-1. Because the AOC was amended to allow the Respondents to develop the BRA, the SCSR was used by A&A as a summary document to assist in preparation of the draft BRA, and it provided an interim evaluation of site conditions for EPA. This revised draft of the BRA supplemented this information with information available in the RI.

A.1.1.2 Objectives of the Baseline Risk Assessment

The specific objectives of this BRA are:

- Estimate the magnitude of potential health risks and environmental impacts associated with the site if no cleanup action was taken;
- Identify the areas, environmental media, and contaminants that pose the primary human health and environmental concerns;
- Identify the areas, environmental media, and contaminants that pose little or no threat to human health or the environment;
- Identify any existing data gaps so that additional information can be collected to support cleanup decisions; and
- Provide a baseline for comparing the protectiveness of cleanup alternatives in the FS, relative to potential human health and environmental impacts.

Each of these objectives is addressed in later sections of this report. The results of the BRA will support various analyses in the FS:

- Help determine whether additional response action is necessary;
- Provide a basis for determining residual contaminant levels that are adequately protective of human health and the environment;
- Provide a basis for comparing potential health impacts of various remedial alternatives; and
- Help support selection of the "no-action" alternative (if appropriate).

A.1.2 BACKGROUND

The information presented in Sections A.1.2.1 through A.1.2.1.4 represents a general description of the West Lake Landfill, its history, and existing contamination.

A.1.2.1 West Lake Landfill Description

The West Lake Landfill is located within the western portion of the St. Louis metropolitan area to the east and south of the Missouri River. The West Lake Landfill is situated approximately one mile north of the intersection of Interstate 70 and Interstate 270 within the city limits of the City of Bridgeton in northwestern St. Louis County. The primary facility, the Laidlaw Landfill (formerly the West Lake Landfill) has an address of 13570 St. Charles Rock Road, St. Louis County, Missouri.

The West Lake Landfill is an approximately 200-acre parcel containing multiple facilities. Taussig Road and agricultural land lie immediately southeast of the West Lake Landfill. St. Charles Rock Road (State Highway Route 180) borders the site on the north. Old St. Charles Rock Road, along with undeveloped land, border the southern and western portions of the West Lake Landfill (Figure A.1-1). The landfill can be divided into six distinct areas (Figure A.1-2) including:

- Area 1 within and adjacent to the North Quarry Pit inactive sanitary landfill;
- Area 2 within the inactive demolition landfill;
- Inactive demolition landfill (excluding Area 2);
- Inactive sanitary landfill;
- North Quarry Pit inactive sanitary landfill (excluding Area 1); and

- South Quarry Pit landfill (the active sanitary landfill).

A surface water retention pond, abandoned leachate lagoons and an active leachate retention pond are associated with the sanitary landfill operations. Also included within the boundaries of the West Lake Landfill, as defined in the Operable Unit 2 Work Plan, are concrete and asphalt batch plants, an automobile repair shop, and a former telephone switching station. These operations are not the subject of the RI/FS for Operable Unit 1 or Operable Unit 2.

A six-foot high chain-link fence with a three-strand barbed wire canopy encloses the entire West Lake Landfill. The main access gate is located on the northeastern perimeter, off of St. Charles Rock Road. An additional gate is located on the southwestern perimeter to provide access to the former borrow area, located across old St. Charles Rock Road. A third gate provides access to the automobile repair shop.

As discussed in Section 5.2 of the RI report, covenant restrictions (see Attachment A.II) have been recorded by each of the owners against their respective parcels and the entire West Lake Landfill (including Areas 1 and 2) prohibiting residential and groundwater use. Construction work, as well as commercial and industrial uses have been precluded on Areas 1 and 2 by a Supplemental Declaration of Covenants and Restrictions recorded by Rock Road Industries, Inc., prohibiting the placement of buildings and restricting the installation of underground utilities, pipes and/or excavation upon its property. The recording information for the restrictive covenants precluding residential use is Book 11208 pages 2499, 2507, and 2514, in the Recorder of Deeds Office for St. Louis County, Missouri. The recording information for the restrictive covenant prohibiting the placement of buildings and restricting the installation of underground utilities, pipes and/or excavation is Book 11427 page 1633 in the Recorder of Deeds Office for St. Louis County, Missouri. Covenant restrictions cannot be terminated without the written approval of the then owners, the Missouri Department of Natural Resources (MDNR), and the EPA.

A.1.2.1.1 Summary of Landfill Operations at the West Lake Landfill

Limestone was quarried from the West Lake Landfill from 1939 to 1988. Beginning in the early 1950s or, perhaps, the late 1940s, portions of the quarried areas and adjacent areas were used for disposal of municipal refuse, industrial solid wastes and construction demolition debris (EMSI 1997a). These activities are associated with the unregulated landfill (EMSI 1997a). After a State landfill permit was obtained in 1974, disposal was performed in the portion of the West Lake

Landfill described below as the North Quarry Pit. Disposal continued in this area until 1985 when the landfill underwent expansion to the southeast in the area described below as the South Quarry Pit. Landfill activities conducted after 1974 within the quarry area are associated with the regulated landfill.

A.1.2.1.2 Other Prior Landfill Operations

In addition to Areas 1 and 2, an inactive demolition landfill and an inactive sanitary landfill area are located in the north central part of the West Lake Landfill. The inactive demolition landfill is located on the southeast side of Area 2, between Area 2 and the landfill entrance road. The inactive sanitary landfill is located southwest of the inactive demolition landfill. As with the landfill operations conducted in Areas 1 and 2, the operations conducted in these areas were also part of the unregulated landfill operations conducted prior to 1974. Wastes disposed of in these areas are believed to consist of sanitary wastes, a variety of other solid wastes, and demolition wastes.

A.1.2.1.3 Current Landfill Operations

The north quarry pit and the south quarry pit, are associated with current landfilling operations. Because disposal activities conducted in these areas are subject to a permit issued by MDNR, information is available regarding current landfill operations and the nature and configuration of the waste materials disposed of in these areas (McLaren/Hart 1994).

A.1.2.1.4 Activities Adjacent To The West Lake Landfill

The area surrounding the West Lake Landfill is heavily developed for commercial/industrial use (Figure A.1-1). The Earth City industrial park is west of the West Lake Landfill, across Old St. Charles Rock Road. Property to the north of the West Lake Landfill, across St. Charles Rock Road, contains commercial, retail, and manufacturing operations. The adjacent property located north and west of Area 2 was previously owned by Ford, and was previously used as farmland but has not been farmed since the 1980s. The property now consists of a buffer zone and Lot 2A-2, also referred to as the Ford property. It is currently being developed as an industrial park. The subdivision plat for the Ford property, known as Crossroads Industrial Park, currently reflects a 1.785-acre buffer created adjacent to Area 2. The buffer includes the area of radiological impacted surface soils identified in the "Phase III Radiological Assessment" performed by Dames and Moore for Ford Financial Services Group in 1991 (Dames and Moore 1991). Figure A.1-3 depicts the zoning in and around the West Lake Landfill, which is predominantly zoned for commercial and manufacturing use (EMSI 1997a).

A.1.2.2 Summary of West Lake Landfill Contamination

The focus of this BRA is Areas 1 and 2 (the on-site areas) and the Ford Property (the off-site area). These areas are discussed briefly below. The overland gamma survey and RI/FS soil sampling program indicate that radiological contamination is localized in Area 1, Area 2 and a limited part of the Ford property (McLaren/Hart 1996a). A fence defines the boundary between the landfill and the Ford property [Figures 1-2 and 1-3 of the Soil Boring/Surface Soil Investigation Report (McLaren/Hart 1996b)]. These three areas are considered in this risk assessment and have been selected for evaluation in the Operable Unit 1 conceptual model.

A.1.2.2.1 Radiological Area 1

Radiological Area 1 is located immediately southeast of the West Lake Landfill entrance. This area was part of the unregulated landfill operations conducted up through 1974 (EMSI 1997a). Based on the drilling logs obtained as part of the RI/FS investigations for OU-1 (McLaren/Hart 1996b), the waste materials consist of municipal refuse with an average thickness of approximately 36 feet.

There is an asphalt entrance road and abandoned parking area located on the northwestern border of Area 1 near the West Lake Landfill office building. The remaining portions of Area 1 are mainly covered with grass. An underground diesel tank is located beneath the asphalt-paved area in the western portion of Area 1. The diesel tank is no longer in use but has not been removed because it is within the boundaries of Area 1.

A.1.2.2.2 Radiological Area 2

Radiological Area 2 is located in the northwestern part of the West Lake Landfill. This area was also part of the unregulated landfill operations conducted prior to 1974. Based on the drilling logs obtained as part of the RI/FS investigations for Operable Unit 1, the waste materials in Radiological Area 2 consist of construction and demolition debris and municipal refuse with an average thickness of approximately 30 feet.

Large portions of this area are covered with grasses, native bushes and trees while other portions are unvegetated and are covered with soil, gravel, concrete rubble and miscellaneous debris consisting of concrete pipe, metal and automobile parts, discarded building materials, and other non-perishable materials. Scattered throughout Area 2 are a number of small depressions, some of which seasonally contain ponded water and phreatophytes such as cattails. The northern and

western portions of Area 2 are bounded by the landfill berm, the slopes of which are covered with a dense growth of trees, vines, and bushes.

A.1.2.2.3 Ford Property

The Ford property borders Radiological Area 2 to the north and west. This area is relatively level and was previously covered with grasses, weeds, and native bushes. As discussed in the RI, vegetative cover and surface soil was scraped off the property. It is currently being developed as an industrial park. The 1.785-acre buffer noted previously within the Ford property includes radiologically impacted surface soils.

A.1.2.2.4 Areal Extent of Radiological Contamination

West Lake Landfill soil contains elevated concentrations of naturally occurring radionuclides from the uranium (U-238), thorium (Th-232), and actinium (U-235) decay series. Radiological contamination is present in Areas 1 and 2 in surface and subsurface soils. In addition, the Ford property has radiological contamination present in surface soils. The estimated areas of contamination are summarized below:

Estimated Areas of Surface and Subsurface Radiological Contamination

Area	Surface (Upper 6") Contamination	Subsurface (Below 6") Contamination	Total Contamination (All Depths)
1	50,700 ft^2	194,000 ft^2	194,000 ft^2
2	469,000 ft^2	817,000 ft^2	834,000 ft^2
Affected Portions of Ford Property	196,000 ft^2	None	196,000 ft^2

Radiologically impacted materials were found to be present in subsurface materials in Area 1 at two different depths. In the northwestern part of Area 1, radiologically impacted materials were identified at depths generally ranging between 0 and approximately 7 feet. In the southeastern portion of Area 1, radiologically impacted materials occur at a somewhat deeper interval ranging from 0 to approximately 15 feet. Radiologically impacted materials were generally found at depths ranging between 0 to approximately 6 feet in the northern portion of Area 2. Deeper occurrences of radiologically impacted materials were identified in a few borings in the northern portion of Area 2 at 8, 11, 19.5, and 20-foot depths. In the southern part of Area 2, radiologically impacted materials were identified at depths generally ranging between 0 and 6 feet. Deeper occurrences of radiologically impacted materials were also identified at 10, 22, and 27-foot

depths. None of the samples collected from the Ford property from depths of 6 inches or more below the ground surface contain any radionuclides with activities above the Remedial Investigation (RI) reference levels. The reference levels for the remedial investigation are discussed in Section 6.3 of the RI report.

A.1.3 ORGANIZATION OF THIS REPORT

The remainder of this report is organized as follows:

- Section 2 reviews the data collection effort and identifies the contaminants of concern;
- Section 3 describes the human exposure assessment, including contaminant fate and transport, potential receptors, exposure routes, and estimated contaminant intakes;
- Section 4 provides human toxicity information for the contaminants of concern;
- Section 5 presents the methodology for, and results of, the health risk characterization;
- Section 6 presents a discussion and summary of the sources of uncertainty assessment;
- Section 7 is the ecological risk assessment;
- Section 8 summarizes the results of the BRA; and
- Section 9 lists the various references used in completing this report.

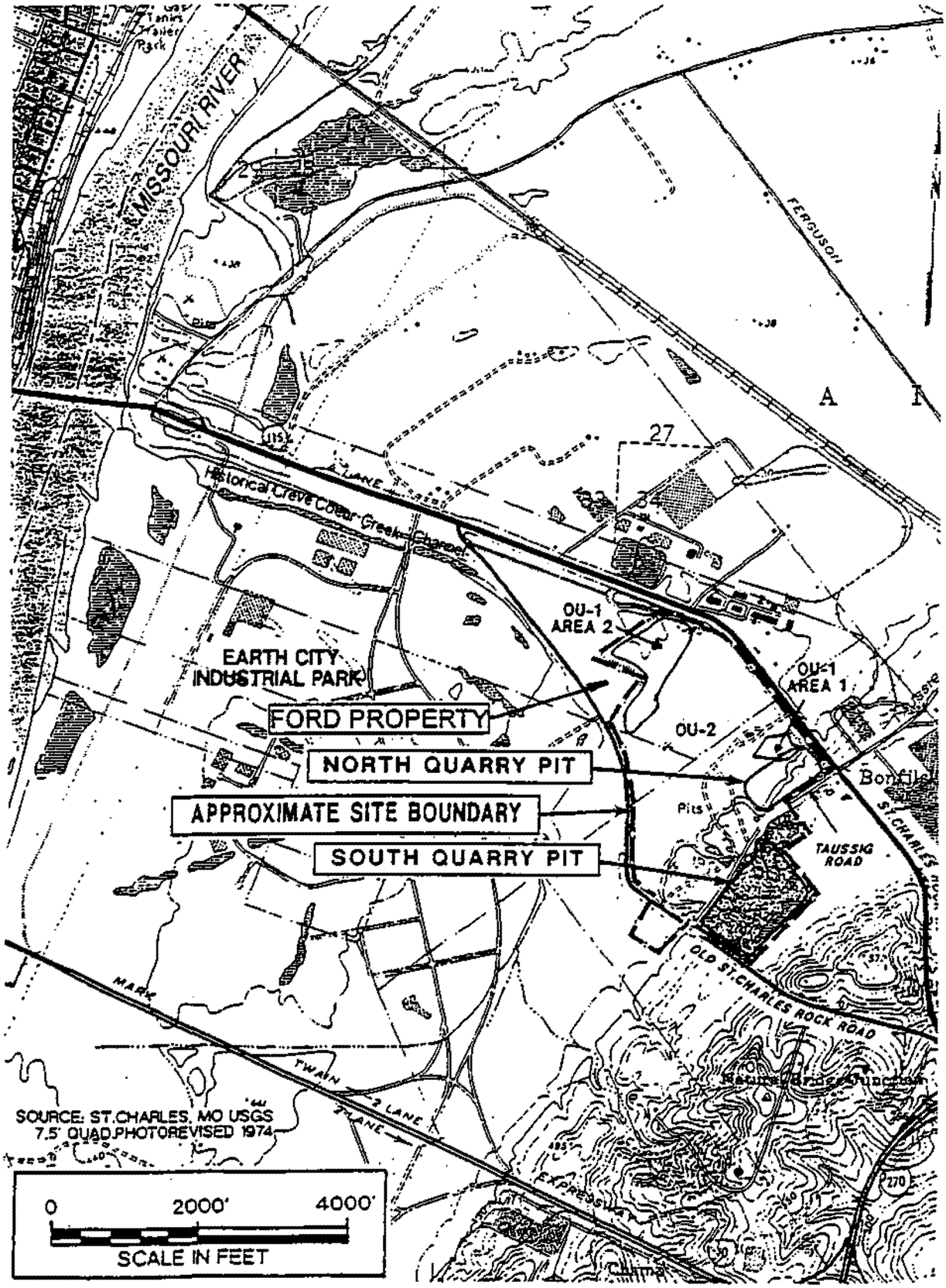


FIGURE A.1-1: Site Location Map

(modified from Golder Associates, 1996, Figure 1-2)

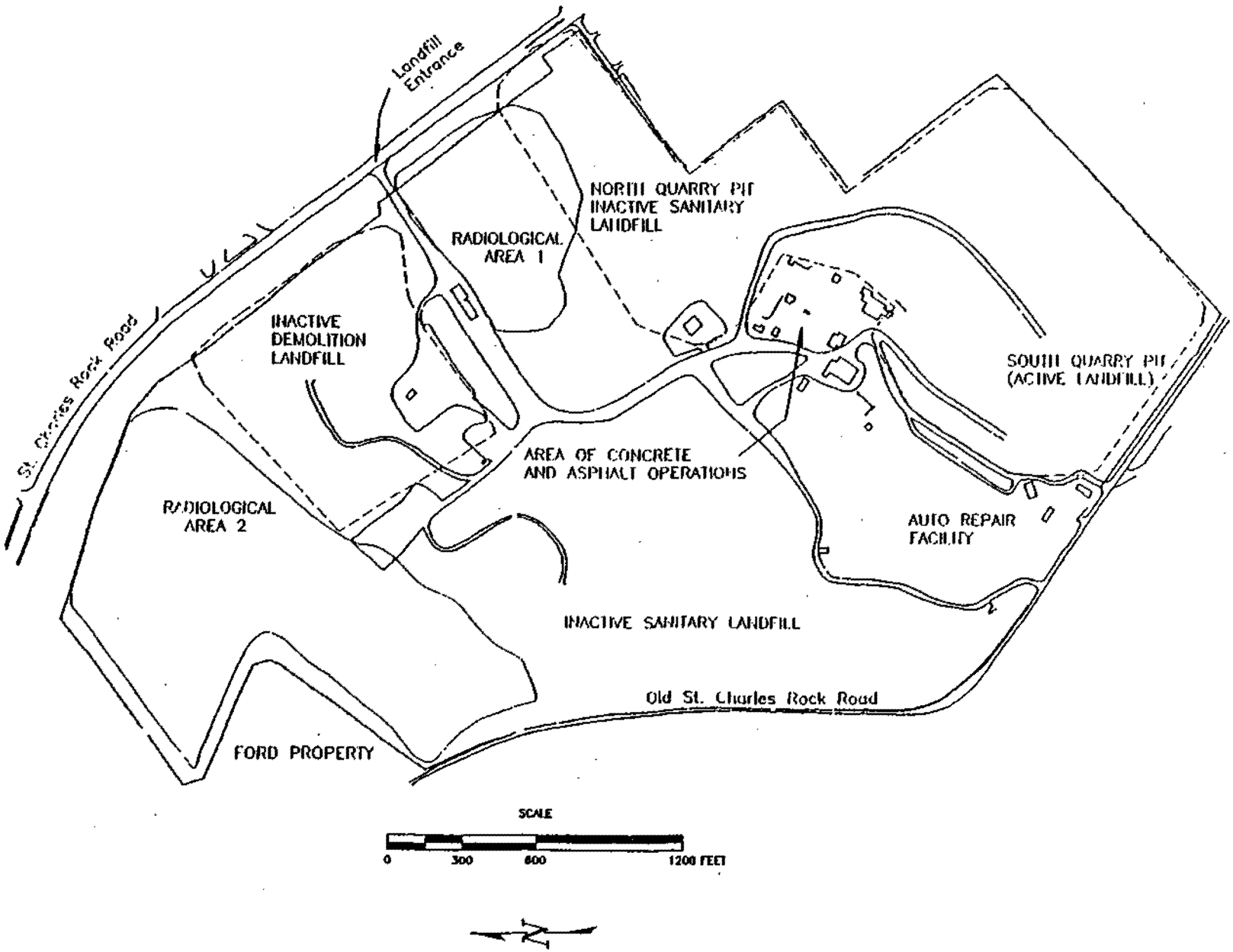
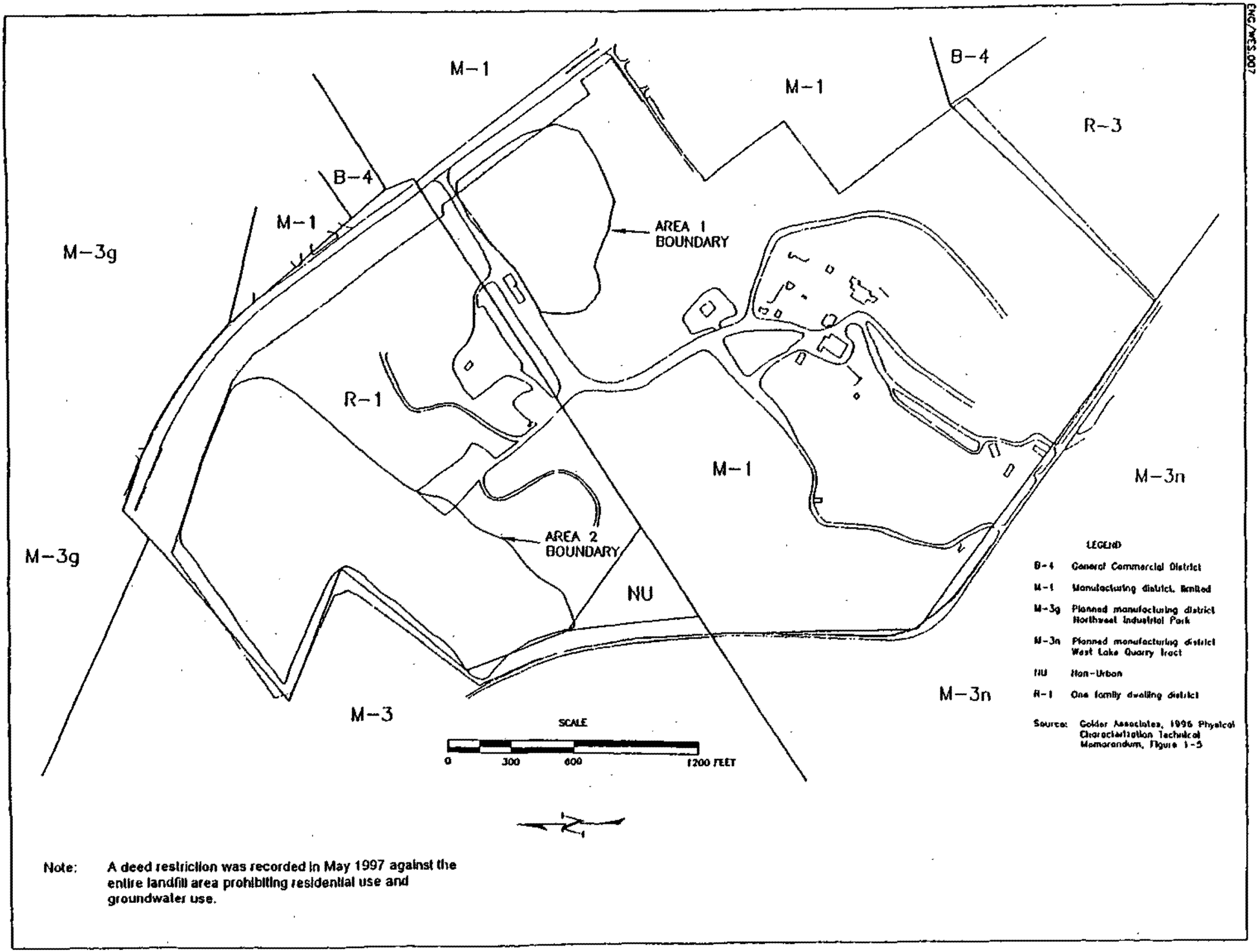


FIGURE A.1-2: Areas of Landfill Operations



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Note: A deed restriction was recorded in May 1997 against the entire landfill area prohibiting residential use and groundwater use.

FIGURE A.1-3: Landfill and Surrounding Area Zoning

A.2.0 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

The information relevant to the collection and evaluation of data, identification of exposure routes and associated radioactive chemicals of potential concern (COPCs) was previously reported in the SCSR (EMSI 1997a). A&A has used the SCSR as the primary source of information regarding radioactive COPCs. Screening and selection of non-radioactive COPCs, based on available characterization data, was also performed as part of the BRA. The selection of COPCs for surface soil and subsurface soil described in this section was performed for the human health risk assessment. The selection of COPCs in environmental media for the ecological risk assessment is addressed in Section A.7.0.

A.2.1 DATA SOURCES FOR CONTAMINANT CONCENTRATIONS

The following documents and characterization data were reviewed by A&A:

"RI/FS Work Plan for the West Lake Site, Bridgeton, Missouri", August 15, 1994 (McLaren/Hart 1994)

"Overland Gamma Survey Report, West Lake Landfill Radiological Areas 1 and 2", April 30, 1996 (McLaren/Hart 1996a)

"Site Reconnaissance Report, West Lake Landfill Radiological Areas 1 and 2", May 16, 1996 (McLaren/Hart 1996c)

"Split Soil and Groundwater Sampling Data Summary Report, West Lake Landfill Areas 1 and 2", November 22, 1996 (McLaren/Hart 1996d)

"Soil Boring/Surface Soil Investigation Report, West Lake Landfill Areas 1 and 2", November 26, 1996 (McLaren/Hart 1996b)

"Interim Investigation Results Technical Memorandum, West Lake Landfill Operable Unit 1", January 28, 1997 (EMSI 1997b)

"Amended Sampling and Analysis Plan, West Lake Landfill Operable Unit 1", January 29, 1997 (EMSI 1997c)

"Site Characterization Summary Report, West Lake Landfill, Operable Unit 1", August 1997 (EMSI 1997a)

"Remedial Investigation Report, West Lake Landfill, Operable Unit 1", April 10, 2000 (EMSI 2000)

A.2.2 REVIEW OF CHARACTERIZATION DATA

The objective of this evaluation is to develop a set of data and information suitable for use in the West Lake Landfill human health risk assessment. The data for Operable Unit 1 were evaluated to establish: (1) which detected chemicals are believed to be site-related, and (2) which data are of sufficient quality for use in the quantitative risk assessment.

A.2.2.1 Selection of Radioactive Constituents of Potential Concern for the Human Health Risk Assessment

Radiological characterization activities at the West Lake Landfill identified the radioactive COPCs as those associated with the naturally occurring uranium-238, thorium-232, and uranium-235 decay series (Figures A.2-1 through A.2-3). A&A performed a technical review of the radiological characterization data. The objective of the review was to identify the appropriate radionuclides from which the source term concentrations could be determined for use in the BRA. For this assessment, the following radionuclides, with relatively long half-lives, were used as indicators of all of the members of the identified decay chains:

ASSESSMENT OF CURRENT RISK

Indicator Radionuclide	Radionuclide or Decay Chain
Uranium-238	For Uranium-238 + 2 Daughters
Uranium-234	For Uranium-234
Thorium-230	For Thorium-230
Radium-226	For Radium-226 + 5 Daughters (including Radon-222)
Lead-210	For Lead-210 + 2 Daughters
Thorium-232	For Thorium-232 + 10 Daughters
[(Uranium-238 + Uranium-234)/2] x 0.05	For Uranium-235 + 1 Daughter
Protactinium-231	For Protactinium-231 + 8 Daughters

ASSESSMENT OF FUTURE RISK

Indicator Radionuclide	Radionuclide or Decay Chain
Uranium-238	For Uranium-238 + 2 Daughters
Uranium-234	For Uranium-234

Thorium-230	For Thorium-230 and as a Source of Radium-226 ingrowth
Radium-226	For Radium-226 + 8 Daughters (including Radon-222 and Lead-210 and its daughters)
Thorium-232	For Thorium-232 + 10 Daughters
[(Uranium-238 + Uranium-234)/2] x 0.05	For Uranium-235 + 1 Daughter
Protactinium-231	For Protactinium-231 + 8 Daughters

Radionuclides were not screened against local background values during the COPC selection process and all detected radionuclides were carried through the risk assessment process. This conservative approach will slightly overestimate the site-related concentrations of the radiological component of the risk assessment.

The radionuclide source term concentrations for assessment of current risk are derived from radiological characterization data for the indicator radionuclides listed above. The source term concentrations for assessment of future risk are the same as for current risk except for the concentration of "Radium-226 + 8 Daughters", which includes the radium-226 calculated to grow in from the current thorium-230 activity during the assessment period of 1000 years.

Note that radon-222, a gas, is a member of the decay chains labeled "Radium-226 + 5 Daughters" and "Radium-226 + 8 Daughters". The corresponding radium concentrations are used in the risk assessment as the radon source terms for evaluation of the potential human health risks from radon exposure routes. The decay chain labeled "Radium-226 + 8 Daughters" also incorporates the lead-210 decay chain, which will come into equilibrium with the radium-226 source term concentration during the assessment period of 1000 years.

Uranium is made up of three naturally occurring isotopes: uranium-234 (U-234), uranium-235 (U-235), and uranium-238 (U-238). If the uranium has not been through an isotopic enrichment process (i.e., enrichment for U-235 through gaseous diffusion), the activity concentration of U-235 is approximately 5% (0.05) of the activity concentration of U-238 in a sample containing uranium. In addition, natural uranium has approximately equal activity concentrations of U-234 and U-238. Therefore, the activity concentration of U-235 is approximately 5% (0.05) of the activity concentration of U-234 in a sample containing uranium. If the concentrations of U-234 and U-238 are measured for a sample and if the uranium is natural uranium, then the activity

concentration of U-235 can be calculated as 5% (0.05) of the average of the U-234 and U-238 concentrations. In other words:

$$\text{U-235 activity} = [(\text{U-238 activity} + \text{U-234 activity}) / 2] \times 0.05 \qquad \text{Eq. A.2-1}$$

The radiological characterization data for U-235 were examined with respect to the corresponding concentrations of U-234 and U-238, as is routine for examination of isotopic uranium analytical results. The U-235 concentrations tabulated in the RI (Tables B-1 to B-4, B-7, and B-8) are higher than one would expect from natural uranium. This discrepancy could be attributable to two reasons: the material could be isotopically enriched in U-235, or the difference could be an artifact of the sample analytical process. If the material had been enriched in U-235 by gaseous diffusion, it would have an even greater enrichment in U-234 with respect to U-238 concentrations. An examination of the isotopic uranium data provided in the RI reveals that U-234 concentrations do not differ significantly from U-238 concentrations in the respective samples. This observation indicates that the uranium has not been enriched. The other possible explanation, that the discrepancy in expected uranium isotopic ratios is an artifact of the sample analytical process, is supported by the fact that U-235 concentrations are commonly overestimated when samples are assayed for uranium isotopes by alpha spectrometry. Therefore, it was concluded that the U-235 characterization results were not reliable and that U-235 concentrations should be calculated for each sample using Equation A.2-1.

The current and future source term concentrations for U-235 used in the BRA have been calculated from the measured concentrations of U-234 and U-238 using Equation A.2-1. This assumption is appropriate because it is reasonable to expect that these three radionuclides exist in the West Lake Landfill in naturally-occurring proportions.

A.2.2.2 Selection of Non-Radioactive Chemicals of Potential Concern for the Human Health Risk Assessment

From the list of organic and inorganic chemicals present, the most significant in terms of toxicity, concentration, and frequency of occurrence were selected as COPCs. Selection of COPCs focuses the human health risk assessment on chemicals that are associated with the operable unit and are most likely to pose a threat to human health. Selection of COPCs in environmental media for the ecological risk assessment is addressed in Section A.7.0.

The non-radioactive data used in the human health risk assessment were tagged with various qualifiers and codes. Data qualified during the validation as rejected data (R) were not used. Data qualified as estimated values (J) were included in the data set.

A toxicity screening procedure was used to identify the chemicals that, based on concentration and toxicity, were most likely to contribute significantly to calculated risks. This procedure was used to focus on the most significant chemicals (EPA 1989a). The screening process was limited to chemicals detected in soils because chemicals detected in operable unit soils represent the sources of contaminants from which receptors might receive the most direct and the greatest potential exposures.

Screening values are calculated concentration values that, due to the conservative nature of their derivation, can be used with a high degree of confidence to indicate whether further action is needed. Screening values inherently incorporate assumptions about land use and contaminant exposure. In identifying COPCs, it is generally accepted that screening values will reflect any potential future land uses.

EPA Region IX has developed risk-based preliminary remediation goals (PRGs) for soils based on either residential or industrial land use (EPA 1999a). These values were derived using conservative assumptions to estimate contaminant concentrations in environmental media (soil, air, and water) that are considered protective of humans, including sensitive groups, over a lifetime. These concentrations are considered to be appropriate for screening the listed contaminants detected in soils.

Residential land use and groundwater wells have been precluded at the West Lake Landfill (including Areas 1 and 2) by Declarations of Covenants and Restrictions recorded by each of the property owners against their respective parcels. Construction work, commercial, and industrial uses have also been precluded on Areas 1 and 2 by a Supplemental Declaration of Covenants and Restrictions recorded by Rock Road Industries, Inc., that prohibits the placement of buildings and restricts the installation of underground utilities, pipes and/or excavation on Areas 1 and 2 (Attachment AII). Based on these observations and considering the degree of commercial/industrial land use in the vicinity of the West Lake Landfill, the EPA Region IX soil PRGs for industrial land-use were selected to derive the soil screening values used to identify COPCs at this site.

EPA Region IX risk-based PRGs values are based on exposure of an industrial receptor via incidental ingestion, inhalation of fugitive dust, inhalation of volatiles, and dermal contact. The published values present concentrations in soils that present an incremental lifetime cancer risk of 1×10^{-6} for carcinogens and a HI = 1 for noncarcinogens. The incremental lifetime cancer risk of 1×10^{-6}, is a conservative value given that it is the lowest value in the range of acceptable carcinogenic risks, 1×10^{-4} to 1×10^{-6} (EPA 1999b). The HI value of 1.0 represents the maximum acceptable value for a chemical. As a conservative health-protective measure, the screening values used for noncarcinogens in this assessment were adjusted to a HI of 0.1. If two PRG values were available for a chemical (i.e., a chemical had both a PRG value based on carcinogenic risk and a IXPRG value based on noncarcinogenic risk), the lower of the two values was used as the soil screening value.

Chromium may exist in two valence states, trivalent (Cr^{+3}) and hexavalent (Cr^{+6}) chromium. Hexavalent chromium is significantly more toxic and more mobile in the environment than Cr^{+3}. However, Cr^{+6} is not naturally occurring and is unstable in the environment, oxidizing to the trivalent state. It is unlikely that the chromium present is hexavalent chromium, because there is no likely source for Cr^{+6}. In addition, the screening value should represent the total chromium present, which includes the naturally occurring trivalent chromium. EPA Region IX has derived a PRG for total chromium, which assumes that there is a 1:6 ratio of Cr^{+6} to Cr^{+3} (EPA 1999a). This value was used as the screening value.

The potential hazard associated with exposure to lead is evaluated based on estimated blood-lead concentrations. For residential properties, the EPA has recommended a screening value of 400 mg/kg, which is based on the residential exposure of children (EPA 1994a). This is a very conservative screening value given that it is based on a residential exposure scenario and uses a child receptor, which has a higher soil ingestion rate than an adult. In addition, a child has a higher absorption rate of lead, up to 50%, as compared to 10-15% for adults (BEIAS 1997). Accordingly, this screening value is not applicable to this site. However, EPA has not developed an industrial screening value for lead, and therefore for the purposes of screening lead values in this risk assessment, the residential screening value of 400 mg/kg was used for a screening value.

There are no screening values for elemental thallium, however, there are screening values for several thallium compounds. The PRG value for thallic oxide, which is the most conservative value, was used in the data screening.

In addition to being a radioactive element, uranium is a heavy metal. Therefore, uranium will also be evaluated in the screening process as a chemical COPC using systemic toxicity data. EPA Region IX does not provide PRGs for uranium. EPA Region III has developed risk-based screening values for soils (EPA 1999c). These values are based on incidental ingestion of soils; therefore, these values do not take into account exposure via inhalation or dermal contact. However, exposure via the inhalation and the dermal pathways are not likely to result in a significant change in the screening value. Uranium does not have either an inhalation reference dose or an inhalation slope factor published by EPA in the Integrated Risk Information System (IRIS) or the Health Effects Assessment Summary Tables (HEAST) (EPA 2000; EPA 1997c). Given the absence of toxicological values for inhalation, exposure via inhalation can not be used in deriving a screening value. The dermal adsorption factor for uranium salts is 0.001 (ORNL 2000). Given the low dermal adsorption rate, it is unlikely that absorption via dermal uptake will be significant relative to the oral exposure pathway. Therefore, the EPA Region III risk-based screening value of 610 mg/kg, will be used for the screening value (EPA 1999c).

Environmental samples were analyzed for total petroleum hydrocarbons (gasoline, diesel and motor oil). Total petroleum hydrocarbons represent a group of chemicals, including alkanes, alkyl benzenes, and polycyclic aromatic hydrocarbons. The toxicity of these mixtures is generally dictated by the concentrations of alkyl benzenes and polycyclic aromatic hydrocarbons. These chemicals have been analyzed separately and are evaluated as potential COPCs. Therefore, total petroleum hydrocarbons will not be addressed as a COPC.

The results of the chemical screening are given in Table A.2-1.

A.2.3 SUMMARY STATISTICS FOR SAMPLE RESULTS

Sample results were grouped separately for Area 1, Area 2, and the Ford property, as each of these represent a different exposure area. These areas were defined by the extent of the overland gamma radiation survey depicted in the Soil Boring/Surface Soil Investigation Report (McLaren/Hart 1996b). The data for each group were further divided to represent two different sampling depths. These groups were surface soil (0-30 cm) and all sampling depths. Sample results from outside of the defined boundaries of these groups were evaluated for elevated concentrations of potential contaminants in soil; data from one additional location were added to the group for Area 1 due to elevated thorium-230 activity. The frequency of detection and the range of detected values for the COPCs for each area and range of sampling depths are presented

in Tables A.2-2 through A.2-7. These tables also list the arithmetic mean of the data sets, with non-detected results included at one-half of the reported detection limit.

During a site walkover conducted on November 18, 1999, Herst & Associates observed that the upper 2 to 6 inches of soil at the Ford property had been scraped from the surface. The date(s) during which this occurred are not known. EMSI prepared an Interim Measures Work Plan (EMSI 1999) and submitted this work plan to EPA to assess the current conditions of the property. Additional sampling was conducted by Herst & Associates on behalf of EMSI on February 14, 2000 and these samples were analyzed for radioisotopes. The analytical results are summarized in Table A.2-8. Considering the change at the Ford property, the exposure assessment and risk assessment for the Ford property were performed using the soil recharacterization data set summarized in Table A.2-8, replacing the data from sampling efforts conducted earlier.

Table A.2-1 Summary of Screening of Non-Radiological Contaminants

Analyte	Risk-Based Industrial Screening Values[a] (mg/kg)	Maximum Soil Concentrations Area 1 0-1 ft. (mg/kg)	Area 2 0-1 ft. (mg/kg)	Ford Property (mg/kg)	Selection/Screening of COPCs in Soils[b] Area 1 0-1 ft	Area 2 0-1 ft	Ford Property
Inorganic Chemicals							
Arsenic	2.70E+00	220	35	[c]	YES	YES	no
Beryllium	3.70E+02	3.3	1.2	2.2	no	no	no
Cadmium	8.10E+01	7.9	3.4	6.3	no	no	no
Chromium	4.50E+02	31	43	49	no	no	no
Copper	7.60E+03	2300	360	160	no	no	no
Lead	4.00E+02 [d]	320	2200	400	no	YES	no
Mercury	6.10E+01	0.17	0.27		no	no	no
Nickel	4.10E+03	3600	680	33	no	no	no
Selenium	1.00E+03		38	0.58	no	no	no
Thallium	1.40E+01	1.2			no	no	no
Uranium	6.10E+02 [e]	437.5	875	12.4	no	YES	no
Zinc	6.10E+04	120	210	400	no	no	no
Organic Chemicals							
Acetone	6.20E+02	0.034	0.038		no	no	no
Bis(2-ethylhexyl) phthalate	1.80E+02	7.8	77		no	no	no
Di-n-octylphthalate	1.80E+03	3	12		no	no	no
1,4-Dichlorobenzene	8.10E+00	0.042	0.0065		no	no	no
Fluoranthene	3.00E+03		8.5		no	no	no
Xylenes	4.50E+02	0.037	0.012		no	no	no
Pesticides/PCBs							
Aldrin	1.50E-01		0.0017		no	no	no
Aroclor 1254	1.00E+00	1.1	1.6		YES	YES	no
4,4'-DDD	1.70E+01		0.0076		no	no	no
4,4'-DDT	1.20E+01		0.0094	0.0068	no	no	no

[a] Unless otherwise noted, values derived using EPA Region IX risk-based preliminary remediation goals based on exposure via soil ingestion, inhalation of resuspended soil, dermal contact with soil, and inhalation of volatiles combined (EPA 1999a).

[b] "YES" signifies analyte is selected for quantitative risk evaluation, "no" signifies the analyte will not be evaluated quantitatively.

[c] Maximum value was below background screening concentration.

[d] Residential value. Industrial value not available.

[e] EPA Region III (EPA 1999b). EPA Region IX value not available.

Table A.2-2 Summary Statistics for Concentration Data from Area 1 Surface Soil

Analyte	Frequency of Detection (Detections/n)	Range of Detections	Arithmetic Mean [a]	Units
Uranium Series				
Uranium-238	5/5	0.88 - 147	51.0	pCi/g
Uranium-234	5/5	1.04 - 154	52.6	pCi/g
Thorium-230	5/5	1.94 - 9700	3510	pCi/g
Radium-226	5/5	0.91 - 906	204	pCi/g
Lead-210	3/5	1.82 - 1040	253	pCi/g
Actinium Series				
Uranium-235	4/5	0.24 - 20	5.48	pCi/g
Protactinium-231	2/5	156 - 544	142 [b]	pCi/g
Thorium Series				
Thorium-232	5/5	0.52 - 35	11.1	pCi/g
Inorganic Chemicals				
Arsenic	5/5	1.40 - 220	47.3	mg/kg
Organic Chemicals				
Aroclor-1254	1/5	1.10 - 1.10	0.2	mg/kg

[a] If the COPC was not detected in the sample, one-half the detection limit was used to represent the COPC concentration in that sample when calculating the mean value.

[b] The average for this COPC is heavily influenced by the use of one-half the detection limit to represent the concentration in samples in which the COPC was not detected.

Table A.2-3 Summary Statistics for Concentration Data from Area 2 Surface Soil

Analyte	Frequency of Detection (Detections/n)	Range of Detections	Arithmetic Mean [a]	Units
Uranium Series				
Uranium-238	12/12	0.71 - 294	37.1	pCi/g
Uranium-234	12/12	0.88 - 575	67.5	pCi/g
Thorium-230	12/12	1.21 - 29240	3990	pCi/g
Radium-226	12/12	0.70 - 3720	501	pCi/g
Lead-210	6/12	1.56 - 1370	170	pCi/g
Actinium Series				
Uranium-235	9/12	0.40 - 251 [b]	25.4	pCi/g
Protactinium-231	3/12	5.22 - 2030	241	pCi/g
Thorium Series				
Thorium-232	10/12	0.31 - 127	16.6	pCi/g
Inorganic Chemicals				
Arsenic	8/8	1.60 - 35.0	8.08	mg/kg
Lead	8/8	32.0 - 2200	555	mg/kg
Uranium[c]				
Organic Chemical				
Aroclor-1254	2/8	1.60 - 1.60	0.55	mg/kg

[a] If the COPC was not detected in the sample, one-half the detection limit was used to represent the COPC concentration in that sample when calculating the mean value.

[b] The uranium-235 analytical result of 251 pCi/g corresponds to sample location WL-209. The corresponding uranium-238 and uranium-234 analytical results are 294 and 575 pCi/g, respectively, indicating that the isotopic uranium results for this sample are not reliable. See the discussion in Section A.2.2.1. The value of 251 was therefore not used in the calculation of the arithmetic mean.

[c] Analyses for total uranium (mg/kg) are not available. Of the isotopes of natural uranium, uranium-238 accounts for more than 99 percent of the mass of uranium. The mass concentration of uranium was calculated in the exposure assessment (Section A.3.0) by dividing the uranium-238 exposure point concentration in picocuries per gram (pCi/g) by the specific activity of 0.336 pCi/ug, resulting in a mass concentration of mg uranium per kg soil (mg/kg).

Table A.2-4 Summary Statistics for Concentration Data from Area 1 All Soil Depths

Analyte	Frequency of Detection (Detections/n)	Range of Detections	Arithmetic Mean [a]	Units
Uranium Series				
Uranium-238	36/38	0.32 - 147	8.80	pCi/g
Uranium-234	37/38	0.35 - 154	8.82	pCi/g
Thorium-230	38/38	0.29 - 9700	512	pCi/g
Radium-226	38/38	0.39 - 906	31.2	pCi/g
Lead-210	18/38	0.72 - 1040	41.8	pCi/g
Actinium Series				
Uranium-235	16/38	0.13 - 20	1.15	pCi/g
Protactinium-231	7/38	0.90 - 544	22.4	pCi/g
Thorium Series				
Thorium-232	32/38	0.08 - 35	2.40	pCi/g
Inorganic Chemicals				
Arsenic	6/6	1.40 - 220	40.2	mg/kg
Organic Chemicals				
Aroclor-1254	1/7	1.10 - 1.10	0.18	mg/kg

[a] If the COPC was not detected in the sample, one-half the detection limit was used to represent the COPC concentration in that sample when calculating the mean value.

Table A.2-5 Summary Statistics for Concentration Data from Area 2 All Soil Depths

Analyte	Frequency of Detection (Detections/n)	Range of Detections	Arithmetic Mean [a]	Units
Uranium Series				
Uranium-238	62/63	0.40 - 294	15.7	pCi/g
Uranium-234	63/63	0.45 - 575	25.8	pCi/g
Thorium-230	63/63	0.50 - 35480	2140	pCi/g
Radium-226	61/63	0.38 - 3720	189	pCi/g
Lead-210	30/63	1.56 - 1370	76.0	pCi/g
Actinium Series				
Uranium-235	24/63	0.16 - 251* [b]	7.22	pCi/g
Protactinium-231	8/63	4.09 - 2030	89.3	pCi/g
Thorium Series				
Thorium-232	46/63	0.18 - 159	9.37	pCi/g
Inorganic Chemicals				
Arsenic	8/8	1.60 - 35.0	8.08	mg/kg
Lead	8/8	32.0 - 2200	555	mg/kg
Uranium[c]				
Organic Chemicals				
Aroclor-1254	2/8	1.60 - 1.60	0.55	mg/kg

[a] If the COPC was not detected in the sample, one-half the detection limit was used to represent the COPC concentration in that sample when calculating the mean value.

[b] The uranium-235 analytical result of 251 pCi/g corresponds to sample location WL-209. The corresponding uranium-238 and uranium-234 analytical results are 294 and 575 pCi/g, respectively, indicating that the isotopic uranium results for this sample are not reliable. See the discussion in Section A.2.2.1. The value of 251 was therefore not used in the calculation of the arithmetic mean.

[c] Analyses for total uranium (mg/kg) are not available. Of the isotopes of natural uranium, uranium-238 accounts for more than 99 percent of the mass of uranium. The mass concentration of uranium was calculated in the exposure assessment (Section A.3.0) by dividing the uranium-238 exposure point concentration in picocuries per gram (pCi/g) by the specific activity of 0.336 pCi/ug, resulting in a mass concentration of mg uranium per kg soil (mg/kg).

Table A.2-6 Summary Statistics for Concentration Data from the Ford Property Surface Soil

Analyte	Frequency of Detection (Detections/n)	Range of Detections	Arithmetic Mean [a]	Units
Uranium Series				
Uranium-238	11/11	0.79 - 4.17	1.29	pCi/g
Uranium-234	11/11	0.69 - 4.05	1.23	pCi/g
Thorium-230	11/11	1.20 - 429	46.1	pCi/g
Radium-226	6/11	1.07 - 17.2	5.33	pCi/g
Lead-210	4/9	4.35 - 49.6	8.03 [b]	pCi/g
Actinium Series				
Uranium-235	9/11	0.06 - 0.31	0.13	pCi/g
Protactinium-231	1/11	7.93 - 7.93	3.85 [c]	pCi/g
Thorium Series				
Thorium-232	11/11	0.43 - 11.2	1.99	pCi/g

[a] If the COPC was not detected in the sample, one-half the detection limit was used to represent the COPC concentration in that sample when calculating the mean value.

[b] Mean does not include two non-detected sample results with very high detection limits (<811 and <1460 pCi/g).

[c] The average for this COPC is heavily influenced by the use of one-half the detection limit to represent the concentration in samples in which the COPC was not detected.

Table A.2-7 Summary Statistics for Concentration Data from the Ford Property 0 - 5 Foot Soil Depths

Analyte	Frequency of Detection (Detections/n)	Range of Detections	Arithmetic Mean [a]	Units
Uranium Series				
Uranium-238	25/25	0.71 - 4.17	1.20	pCi/g
Uranium-234	25/25	0.65 - 4.05	1.13	pCi/g
Thorium-230	25/25	0.68 - 429	21.4	pCi/g
Radium-226	14/25	0.85 - 17.2	4.01	pCi/g
Lead-210	8/23	2.08 - 49.6	5.90 [b]	pCi/g
Actinium Series				
Uranium-235	20/25	0.06 - 0.38	0.15 [c]	pCi/g
Protactinium-231	1/25	7.93 - 7.93	3.41	pCi/g
Thorium Series				
Thorium-232	25/25	0.10 - 11.2	1.34	pCi/g

[a] If the COPC was not detected in the sample, one-half the detection limit was used to represent the COPC concentration in that sample when calculating the mean value.

[b] Mean does not include two non-detected sample results with very high detection limits (<811 and <1460 pCi/g).

[c] The average for this COPC is heavily influenced by the use of one-half the detection limit to represent the concentration in samples in which the COPC was not detected.

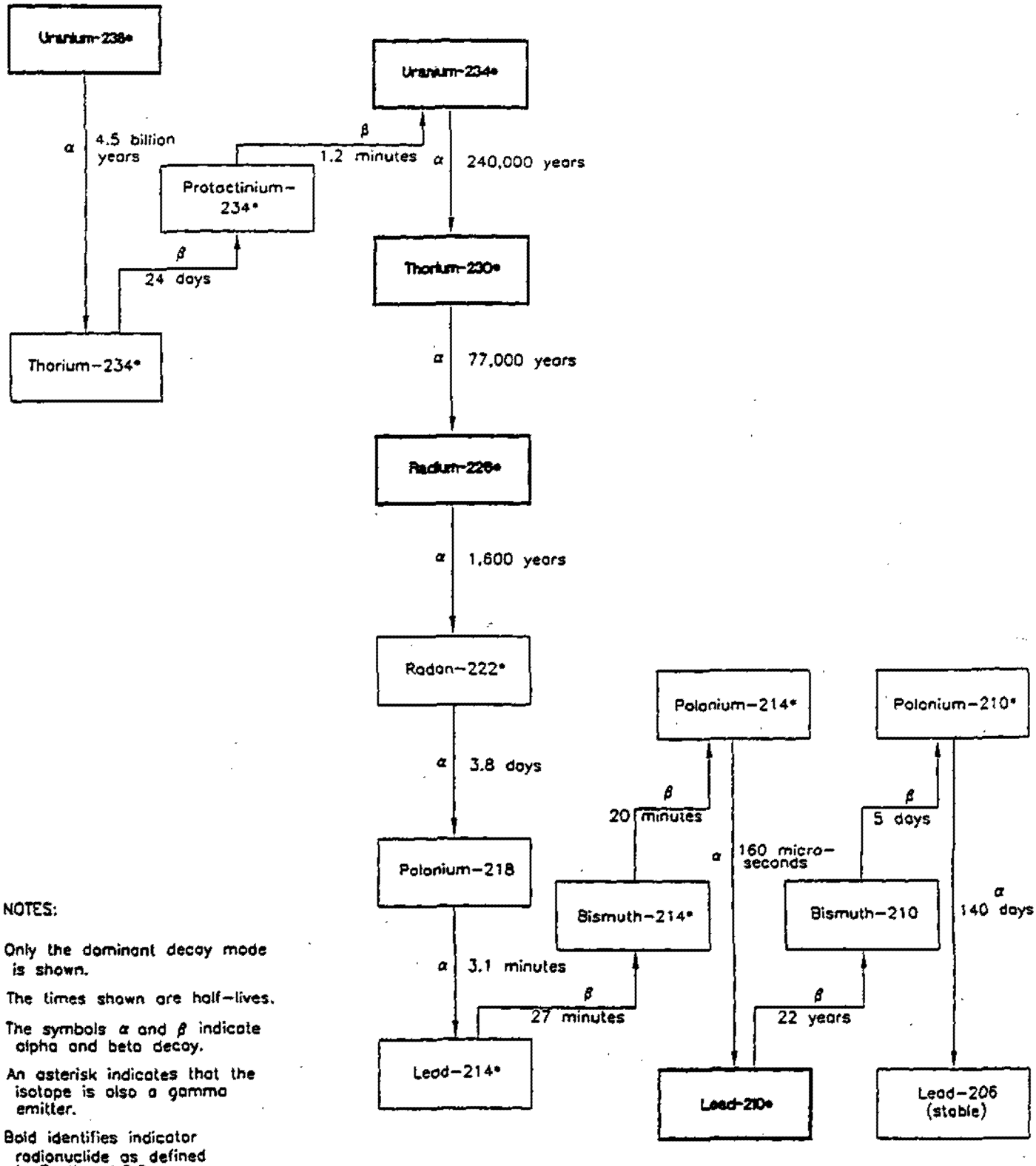
Table A.2-8 Summary Statistics for COPC Concentration Data in Recharacterized Ford Property Soil

Analyte	Frequency of Detection (Detections/n)	Range of Detections	Arithmetic Mean [a]	Units
Uranium Series				
Uranium-238	7/7	0.69 - 1.08	0.911	pCi/g
Uranium-234	7/7	0.63 - 1.06	0.900	pCi/g
Thorium-230	7/7	2.48 - 30.6	7.5	pCi/g
Radium-226	7/7	0.62 - 1.55	0.84	pCi/g
Lead-210	7/7	1.75 - 5.9	3.26	pCi/g
Actinium Series				
Uranium-235	3/7	0.06 - 0.14	0.08	pCi/g
Protactinium-231	0/7	0.00 - 0.00	1.70 [b]	pCi/g
Thorium Series				
Thorium-232	7/7	0.97 - 1.6	1.26	pCi/g

[a] If the COPC was not detected in the sample, one-half the detection limit was used to represent the COPC concentration in that sample when calculating the mean value.

[b] The average for this COPC is heavily influenced by the use of one-half the detection limit to represent the concentration in samples in which the COPC was not detected.

ENG/WES.002



NOTES:

Only the dominant decay mode is shown.

The times shown are half-lives.

The symbols α and β indicate alpha and beta decay.

An asterisk indicates that the isotope is also a gamma emitter.

Bold identifies indicator radionuclide as defined in Section A.2.0.

FIGURE A.2-1: Uranium-238 Radioactive Decay Series

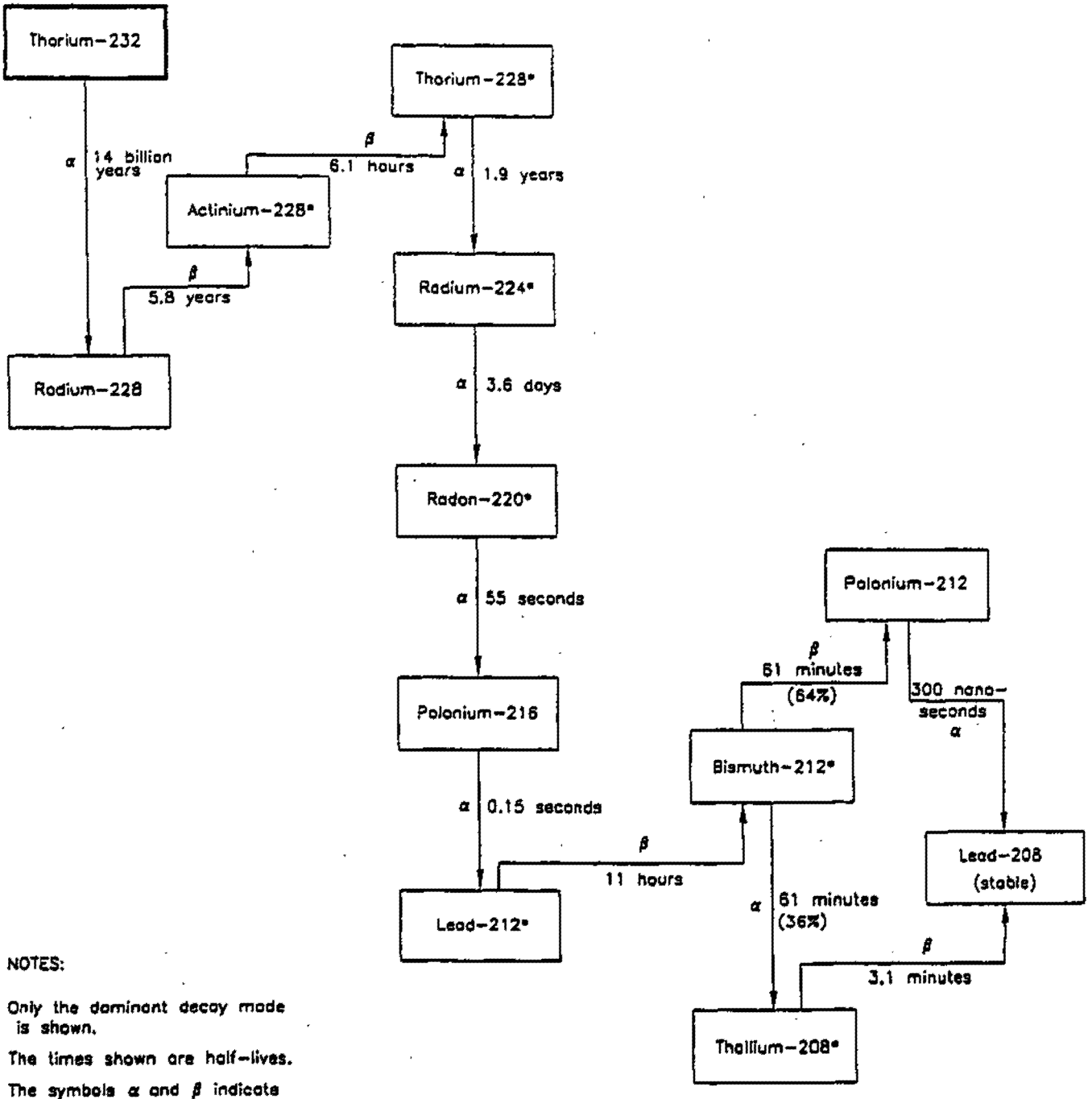


FIGURE A.2-2: Thorium-232 Radioactive Decay Series

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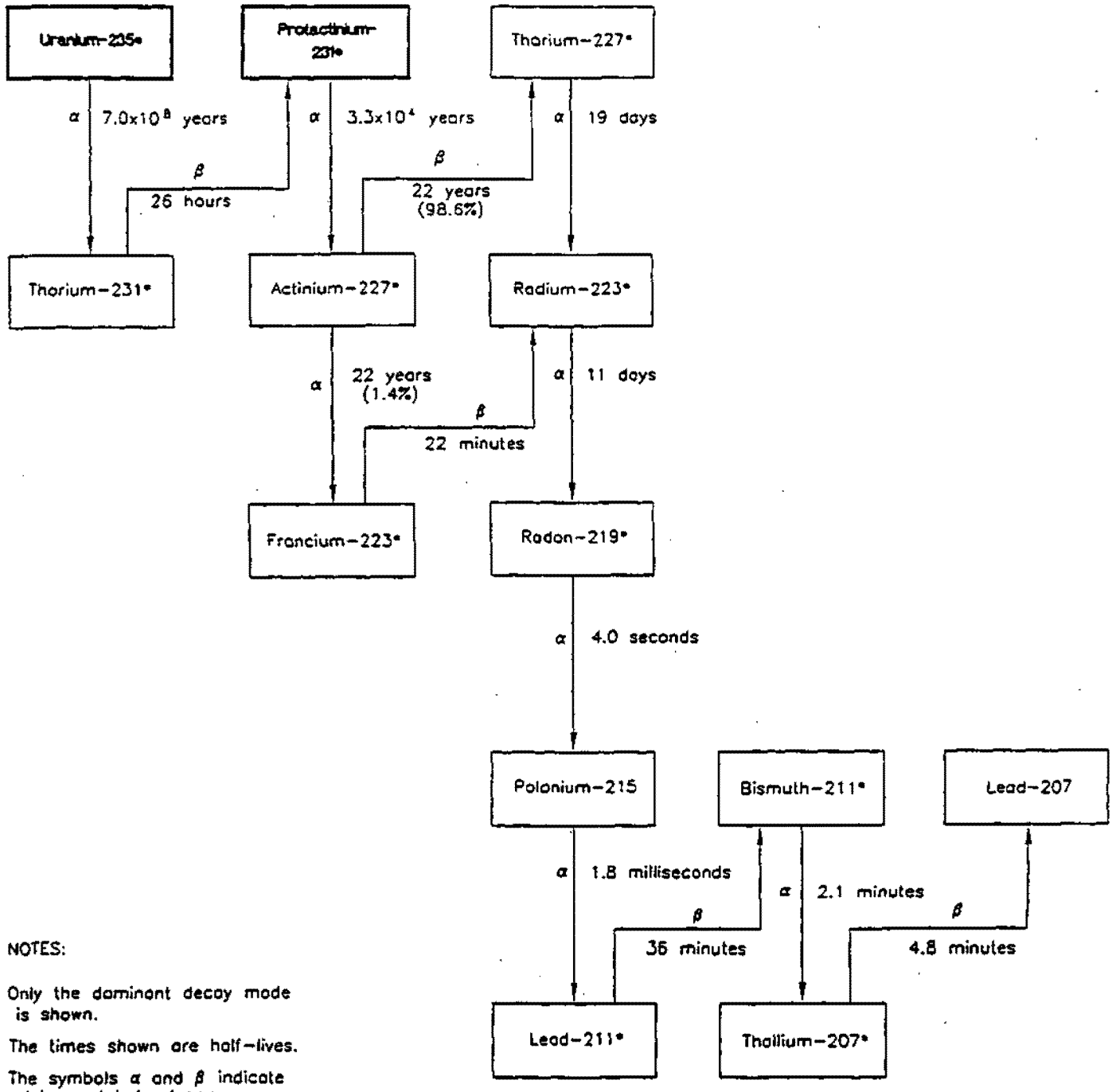

NOTES:

Only the dominant decay mode is shown.

The times shown are half-lives.

The symbols α and β indicate alpha and beta decay.

An asterisk indicates that the isotope is also a gamma emitter.

Bold identifies indicator radionuclide as defined in Section A.2.0.

FIGURE A.2-3: Uranium-235 Radioactive Decay Series

A.3.0 HUMAN EXPOSURE ASSESSMENT

The purpose of an exposure assessment is to estimate the nature and magnitude of exposures from a site under current and plausible future conditions. This is accomplished by following a phased approach that involves the following tasks:

- Characterizing the exposure setting on and around the site,
- Identifying potentially complete human exposure pathways,
- Estimating the exposure point concentrations at the receptor locations, and
- Quantifying the magnitude of plausible contaminant intakes by hypothetical receptors.

This section presents a description of the methods used to evaluate exposures from Operable Unit 1 of the West Lake Landfill, and the results of that assessment. The setting and physical characteristics of Operable Unit 1 are discussed in the SCSR (EMSI 1997a) and the draft RI (EMSI 2000) and are summarized below in Section A.3.1. Section A.3.2 presents the conceptual model describing the sources, contaminant migration, receptors, and exposure routes evaluated for Operable Unit 1. Chemicals of potential concern (COPCs) have been previously identified in Section A.2.0. Estimated exposure point concentrations for these COPCs for each medium of concern - i.e. soil, air, and surface water - are presented in Section A.3.3. The methods used to quantify potential intakes by hypothetical receptors and the estimated intakes are presented in Section A.3.4. Calculated intakes of COPCs are given in Section A.3.5.

A.3.1 CHARACTERIZATION OF EXPOSURE SETTING

The following discussion provides a basis for assessing potential impacts to the various environmental resources associated with the West Lake Landfill and identifying exposure pathways for potential human receptors. The exposure setting is characterized by both the natural environment at the site and the local land use and demography. This section includes a description of the West Lake Landfill topographic conditions, surface soil conditions, runoff drainage patterns, surface water bodies in the area, and current land uses at and near the West Lake Landfill.

A.3.1.1 Climate and Meteorology

The St. Louis area has a modified continental climate characterized by moderately cool winters and warm summers. Temperatures measured from 1958 through 1988 ranged from -28°C

(-18°F) to 42°C (107°F). Evapotranspiration and precipitation in the area generally balance each other. Annual precipitation typically totals approximately 86 centimeters (cm) (34 in.), of which about 25 cm (10 in.) occurs in the spring. Thunderstorms usually occur between 40 and 50 days per year; as much as 25 cm (10 in.) of rain has been recorded in 24 hours during a heavy storm. Winter is the driest season, with precipitation averaging about 15 cm (6 in.). From 1937 through 1988, annual snowfall in the area averaged 50 cm (20 in.); most snowfalls occur from December through March.

A.3.1.2 Topography

The West Lake Landfill is situated on the eastern edge of the Missouri River floodplain. The Missouri River is located approximately two miles to the west of the West Lake Landfill. The river flows in a predominantly north-northeasterly direction in the vicinity of the West Lake Landfill at an elevation of approximately 425 feet based on the National Geodetic Vertical Datum (NGVD). The river is separated from the surrounding areas by a levee system constructed to an average elevation of approximately 435 to 440 feet in this area (McLaren/Hart 1994).

The West Lake Landfill is located in an area that is transitional between the floodplain immediately to the west and the loessial bluffs approximately one-half mile to the east. The edge of the alluvial deposits associated with the river valley is oriented north to south through the center of the West Lake Landfill. The topography of this area is gently rolling ranging in elevation from approximately 430 to 500 feet (NGVD). West Lake Landfill elevations (exclusive of the quarry areas) range from approximately 450 to 500 feet (NGVD). The West Lake Landfill topography has been significantly altered by: 1) quarry activities in the eastern portion of the West Lake Landfill, 2) placement of mine spoils (unused quarry material), and 3) landfill materials in the western portion of the West Lake Landfill.

Area 1 is situated on the north and western slopes of a topographically high area within the landfill. Ground surface elevation varies from 490 feet above mean sea level (AMSL) on the south to 452 feet AMSL at the roadway near the West Lake Landfill property entrance.

Area 2 is situated between a topographic high of landfilled material on the south and the Ford property on the north. The highest elevations are in the southwest of Area 2 where the flank of the topographic high of landfilled materials extends into this area. The topographic high in this area is about 500 feet AMSL sloping to approximately 470 feet AMSL, near the top of the

landfill berm along the south side of the Ford property. The northern portions of the landfill are bounded by a large berm. As a result, the upper surface of Area 2 is located approximately 20 to 30 feet above the adjacent Ford property on the north and west and above the north surface water body, discussed below in Section A.3.1.3, located in the northernmost corner of the West Lake Landfill. The upper surface of Area 2 is approximately 30 to 40 feet higher than the water surface in the flood control channel, discussed below in Section A.3.1.3, that is located to the west of Area 2.

The majority of Area 2 slopes to the north-northeast; however, the surface is irregularly graded with elevations varying from 460 to 480 feet AMSL. A large topographic depression is located near and along the northern berm of the landfill. The elevation of the bottom of this closed depression is 456 feet AMSL.

A.3.1.3 Surface Hydrology

Runoff from Area 1 ultimately flows into the surface water body located north of Area 2 (the north surface water body). Runoff from Area 2 flows into a closed topographic depression located behind the landfill berm, into the north surface water body, or to the south down the landfill access road and ultimately into the north surface water body. A very limited volume of runoff may flow through the breach in the Area 2 berm down the landfill slope and onto the margin of the Ford property. Although a portion of Area 2 is bounded by the flood control channel discussed below, no runoff from Area 2 flows into this water body.

A.3.1.3.1 Area 1 Drainage

The majority of the runoff from Area 1 ultimately flows into the north surface water body. Four locations (Weirs 1, 2, 3, and 4) where rainwater runoff flows from Area 1 were identified. All four locations are in the northern portion of Area 1 and discharge into the drainage ditch located on the south side of the West Lake Landfill entrance road. Flow in this ditch occurs in a northeasterly direction and exits the West Lake property through a culvert beneath the entrance road near the property fence-line. From here, runoff flows in a ditch located along the east side of St. Charles Rock Road and ultimately into the north surface water body located at the northernmost end of the West Lake Landfill.

As previously indicated, the ground surface of Area 1 is irregular and some of the runoff flows into, and accumulates in, several small topographic depressions in this area. Standing water of

up to six inches in depth has been reported to be present in these topographic lows following precipitation events.

A.3.1.3.2 Area 2 Drainage

The majority of the runoff from Area 2 flows into the closed topographic depression located in the southeastern portion of Area 2. Runoff flows off site from Area 2 at five locations that were identified by McLaren/Hart (McLaren/Hart 1996c and 1996e). Three of these locations (Weirs 5, 6 and 7) are at the top of the slope above the landfill berm in the western portion of Area 2 above the buffer on the Ford property. These locations were identified by erosional runnels. With the exception of one heavy storm in mid-May 1995, flow was only observed at one of these locations. This location, Weir 5, is located in the vicinity of the historic berm failure and resulting erosional runoff that led to the accumulation of radiologically-impacted soil in the southern portion of the Ford property. At the other two locations, water has to pond up to a sufficient height to over-top a berm at the top of the landfill slope before any flow will occur. Based on observations made throughout the course of the RI field investigations, it was concluded by McLaren/Hart that this is not a frequent occurrence.

Two additional locations of off-site flow (Weirs 8 and 9) are located in the southern portion of Area 2 near the roadway in the area used for storage of roll-off bins. These areas appear to be areas where runoff occurs primarily as sheet flow and extensive erosional runnelling was not observed in this area. Runoff from the roll-off storage bin area and the demolition landfill area joins runoff from Area 2 near Weirs 8 and 9.

A.3.1.3.3 Surface Water

There are two surface water bodies present in the vicinity of Operable Unit 1. These are the north surface water body and the flood control channel associated with Earth City. There are two additional water bodies present, the surface water detention pond and the leachate lagoon that are associated with the current landfilling operations. As discussed above, runoff from Area 2 has not reached the flood control channel. In addition, the surface water detention pond and the leachate lagoon are all hydraulically isolated from Area 1 and Area 2 so they cannot receive any surface water runoff from these regions.

The north surface water body receives water from the drainage ditch that separates St. Charles Rock Road from the West Lake Landfill. The body contains water throughout the year.

Measurements made by McLaren/Hart indicate a water level fluctuation between approximately 435.4 and 437.3 feet (NVGD).

The flood control channel is part of an extensive set of interconnected channels that are used to maintain drainage within Earth City. Water levels in the channel generally remain relatively constant throughout the year. The water level is controlled by the city of Earth City by pumping large volumes of water to the Missouri River. Measurements made by McLaren/Hart indicate a water level fluctuation between approximately 432.5 and 434.5 feet (NVGD).

A.3.1.4 Surface Soils

According to the U.S. Soil Conservation Service (SCS), surficial soils along the floodplain of the Missouri River generally consist of Blake-Eudora-Waldron association while the surficial soils on the bluffs east of the river are the Urban Land-Harvester-Fishpot association (DOA 1982). The floodplain materials are described as nearly level, somewhat poorly drained to well drained, deep soils formed in alluvial sediment. The upland materials are urban land and nearly level to moderately steep, moderately well drained to somewhat poorly drained, deep soils formed in silty fill material, loess, and alluvium which are formed on uplands, terraces, and bottom lands.

Soil materials present as cover materials in and on the surface of Areas 1 and 2 were derived primarily from on-site materials and from quarry fines consisting primarily of shale materials. The only known exception to the use of on-site soils was the reported use of approximately 39,000 tons of soil mixed with 8,700 tons of leached barium sulfate originating from uranium-ore processing operations which the landfill owner and operator believe was used as cover materials.

A.3.1.5 Subsurface Features

The subsurface conditions beneath the landfill consist of municipal refuse, construction and demolition debris, other wastes and the associated soil cover materials, alluvial deposits and limestone, dolomite, and shale bedrock.

The various areas of landfill activities were previously described in Section A.1.2. The deposits associated with past landfill operations primarily include municipal refuse, construction and demolition fill, and associated soil cover.

A.3.1.6 Hydrology

The hydrogeology of the West Lake Landfill is dominated by a water table aquifer contained within the alluvial materials beneath the West Lake Landfill (EMSI 1997a).

A.3.1.6.1 Water Supply Wells in the Vicinity of the West Lake Landfill

No public water supply wells within the vicinity of the West Lake Landfill obtain any water from the alluvial aquifer (Foth and Van Dyke 1989). Twenty-six private water supply wells were identified in 1989 within a three-mile radius of the West Lake Landfill (Foth and Van Dyke 1989). None of the wells located within a 1-mile radius of the West Lake Landfill are used as a drinking water source. The distribution of private wells in the vicinity of the West Lake Landfill is as follows (Foth and Van Dyke 1994):

- Four wells are reportedly located less than one mile from the West Lake Landfill; however, two no longer exist and the remaining two are not used as drinking water sources (their uses are discussed below);
- Seventeen wells located between one and two miles from the West Lake Landfill including four wells used for irrigation purposes, one well at an abandoned site, and twelve wells used as drinking water sources; and
- Five wells located between two and three miles from the West Lake Landfill, all of which are used as drinking water sources.

The two private groundwater wells within one mile of the West Lake Landfill are used for monitoring and commercial purposes, and neither is used as a drinking water source (Foth and Van Dyke 1994). These include the private well located at the Old Bridge Bait Shop that is 5,100 feet northwest from the West Lake Landfill boundary and a private "shop well" located 4,600 feet northeast from the West Lake Landfill boundary. The nearest well reportedly used as a drinking water source is located approximately 5,300 feet north of the West Lake Landfill. The number of private wells has likely decreased since 1989 due to urban and suburban development and flooding of the area in 1993 and 1995.

A.3.1.6.2 Hydrogeology

The West Lake Landfill is located on the eastern edge of the historic Missouri River Valley along the transition between the alluvial floodplain to the west and the loess bluffs to the east. Areas 1 and 2 are underlain by alluvial deposits of varying thickness. The landfill debris varies in

thickness from 5 to 56 feet, with an average thickness of approximately 36 feet in Area 1 and approximately 30 feet in Area 2. The underlying alluvium increases in thickness from east to west beneath Area 1. The alluvial thickness beneath the southeastern portion of Area 1 is less than 5 feet (bottom elevation of 420 feet AMSL) while the thickness along the northwestern edge of Area 1 is approximately 80 feet (bottom elevation of 370 feet AMSL). The thickness of the alluvial deposits beneath Area 2 is fairly uniform at approximately 100 feet (bottom elevation of 335 feet AMSL).

During the RI investigations, groundwater was generally encountered in the underlying alluvium near or immediately below the base of the landfill debris. Isolated bodies of perched water were encountered in two of the 24 soil borings drilled in Area 1 and six of the 40 soil borings drilled in Area 2 as part of the RI field investigations. The perched water generally occurs in small isolated units at depths varying from five to 30 feet below ground surface.

Groundwater flow beneath Areas 1 and 2 occurs in the underlying alluvium and is influenced by: 1) dewatering effects associated with the former limestone quarry and the current leachate collection activities, 2) infiltration and localized ponding of storm water on the surface of the landfill, 3) infiltration through various drainage ditches located on and off of the West Lake Landfill, and 4) the flood control channel located on the western margin of Area 2.

Monthly groundwater levels were measured in various wells during the first year of the RI investigations and on a quarterly basis during the second year. These data indicate that with the exception of the localized perched water conditions encountered in isolated areas within the landfill, groundwater generally occurs only in the underlying alluvium at or below the base of the landfill materials. Depths to groundwater vary from 15 to 20 feet at the off-site locations, where no filled materials are present, and up to 60 feet at locations inside the West Lake Landfill boundaries. Groundwater elevations varied seasonally and were generally lowest during the fall and winter months (September through March) and highest during the spring and summer months (April through August).

The RI data indicate that only a very small amount of relief (less than one foot) exists in the water table surface beneath the landfill. Based on the water level data, the inferred direction of groundwater flow beneath Area 1 is to the south toward the active landfill. Presumably this flow

is in response to the active dewatering and leachate collection activities conducted in conjunction with the landfill operations.

Aquifer testing consisting of slug tests was performed on 18 wells located throughout the West Lake Landfill to assess the hydraulic conductivity of the underlying alluvium. Testing was performed in six shallow alluvial wells (wells completed near the top of the alluvial materials immediately below the landfill materials), six intermediate wells and six deep wells (wells completed near the base of the alluvium near the bedrock contact). Results of the aquifer testing indicated that the alluvial materials possess hydraulic conductivity values on the order of 3×10^{-2} centimeters per second (cm/sec) ranging from 8.76×10^{-4} cm/sec to 8.85×10^{-2} cm/sec. Although the amount of available data is limited, these results indicate that the hydraulic conductivity values are slightly greater in the lower portions of the alluvium.

A.3.1.7 Vegetation and Wildlife

An assessment of the plant communities present at the West Lake Landfill, including the potential for the presence of threatened or endangered species and a description of the types of wildlife observed to be present at the West Lake Landfill was performed by McLaren/Hart (1996f) as part of the RI/FS investigations. The results of that survey are presented in the SCSR (EMSI 1997a).

A.3.1.7.1 Threatened and Endangered Species

Federal and State listings of threatened and endangered species were requested from the U.S. Fish & Wildlife Service (USFWS) and from the Missouri Department of Conservation (MDOC) by McLaren/Hart as part of their activities related to preparation of the RI/FS Work Plan (McLaren/Hart 1994). The USFWS responded that "No federally-listed endangered or threatened species occur in the project area" (USFWS 1994). The MDOC responded that "Department staff examined map and computer files for federal and state threatened and endangered species and determined that no sensitive species or communities are known to occur on the immediate site or surrounding area" (MDOC 1994).

A.3.1.7.2 Wildlife

Numerous species and signs of species of wildlife were observed to be present in the West Lake Landfill area during the activities associated with the biological survey. Deer tracks (*Odocoileous spp.*) were noted by McLaren/Hart (1996f) in Area 2 and on the adjacent Ford property. Based on the home range of deer, it is likely that all areas of the West Lake Landfill are accessible to this species. Rabbits (*Sylvilgus floridanus*) or signs of rabbits were observed in

Areas 1 and 2, areas surrounding the north surface water body and the Ford property. It is likely that rabbits are cosmopolitan throughout the West Lake Landfill. Other cosmopolitan species include red-winged black birds (*Aeqlaius phoeniceus*), robins (*Turdus migratorius*) and crows (*Corvus brachynchos*).

A great blue heron (*Ardea herodias*), a piscivorous bird, was observed flying above the West Lake Landfill and landing in the south flood control channel (McLaren/Hart 1996f). This species is likely to use aquatic habitats both on and off site, but it will feed only in those waters containing prey species of fish and amphibians.

Several fecal pellets containing fur were observed in Areas 1 and 2 and a relatively large den was observed in the landfill berm along the northwest side of Area 2 (McLaren/Hart 1996f). These fecal pellets and the den were possibly due to coyotes (*Canis latrans*), red fox (*Vulpes*) or possibly both. The home range of these species is large enough to include the entire West Lake Landfill and the presence of rabbits suggests a food source for these species (McLaren/Hart 1996f).

A.3.1.8 Land Use

A.3.1.8.1 Current Land Use

The West Lake Landfill is located in a predominately industrial area. The southern portion of the West Lake Landfill is zoned M-1 (manufacturing district, limited). The southernmost portion of the West Lake Landfill is permitted for active sanitary landfill operations (Permit No.118912). Although the northern portion of the West Lake Landfill is zoned R-1 (one family dwelling district), deed restrictions have been recorded against the entire West Lake Landfill. Residential land use and groundwater use have been precluded at the West Lake Landfill (including Areas 1 and 2) by restrictive covenants (see Attachment A.II) recorded by each of the property owners against their respective parcels. Construction work, commercial and industrial uses have also been precluded on Areas 1 and 2 by a Supplemental Declaration of Covenants and Restrictions recorded by Rock Road Industries, Inc. prohibiting the placement of buildings and restricting the installation of underground utilities, pipes and/or excavation upon its property. The covenant restrictions cannot be terminated without the written approval of the then owners, MDNR, and EPA.

Currently, portions of the West Lake Landfill are used as an active landfill. Access to Operable Unit 1 is restricted to remediation workers. Landfill workers are not allowed access to the two areas, and no operations are conducted in Operable Unit 1 by any other personnel. Operable Unit 1 is not likely to attract curious individuals passing by, and no residents live close enough to the West Lake Landfill to trespass on a regular or intermittent basis.

A small area of the Ford property contains elevated levels of some COPCs in surface soils. This property is outside of the landfill property fence and access to this property is not restricted.

A.3.1.8.2 Future Land Use

For the purposes of the risk assessment it was assumed that the current covenant restrictions remain in effect. This assumption is reasonable because the current covenant restrictions cannot be terminated without the written approval of the then owners, MDNR, and EPA.

A.3.1.9 Demography

The property to the north of the West Lake Landfill, across St. Charles Rock Road, is moderately developed with commercial, retail, and manufacturing operations. The Earth City industrial park is located adjacent to the West Lake Landfill on the west, across Old St. Charles Rock Road. The nearest residential development, "Spanish Village", is located south of the West Lake Landfill near the intersection of St. Charles Rock Road and I-270 approximately ¾ mile from Area 1 and one mile from Area 2. Mixed commercial, retail, manufacturing, and single family residential uses are present to the southeast of the West Lake Landfill.

A.3.1.10 Critical Subpopulations

According to the EPA Guidance (EPA 1989a), a baseline risk assessment must identify subpopulations of potential concern, if they exist, that could be at increased risk from radionuclide or chemical exposure from increased sensitivity, behavior patterns, and current or past exposures from other sources. These populations could include infants and children, the elderly, pregnant and nursing women, individuals with chronic illnesses, and individuals previously exposed to chemicals or radionuclides during occupational activities or by residing in industrial areas. No critical subpopulations have been reported or identified for the immediate vicinity of the site.

A.3.2 CONCEPTUAL MODEL FOR OPERABLE UNIT 1

A conceptual model for Operable Unit 1 has been developed as part of the baseline risk assessment. The conceptual model illustrated in Figure A.3-1 facilitates evaluation of the risks to human health by providing a basis for identifying and evaluating potential risks to human health from contaminants detected in Operable Unit 1. It is based on the following assumptions:

- The property is currently partially covered with vegetation. This vegetative cover can become sparser or more dense as time progresses, and is dependent on future land uses.
- The infiltration rate of water through the West Lake Landfill soil does not change during the 1000-year study period.
- Surface water runoff is currently collected and channeled by the existing containment ditches and ponds.
- The future source term is unaffected by chemical degradation during the study period of 1000 years.
- Radiological decay and associated daughter ingrowth over 1000 years will change the concentrations of the radionuclides in a predictable manner.
- Deed restrictions on the West Lake Landfill prohibit residential use and groundwater use in the future, and a deed restriction on Areas 1 and 2 prohibits construction of buildings, installation of underground utilities or pipes, and excavation within the bounds of the operable unit.

A source of COPCs, a release mechanism, an exposure route, and a receptor are all necessary components of a complete exposure pathway. If any one of these elements is missing, the exposure pathway is incomplete and no exposure can occur. Information about these elements (Section A.3.2.1 through A.3.2.4) and their interrelationships has been used to identify complete exposure pathways and to select potential exposure scenarios to be quantified in this risk assessment (Section A.3.2.5).

Figure A.3-1 and Table A.3-1 can be used to trace the exposure pathways and receptors for Operable Unit 1 from the source through primary release mechanisms, secondary sources and release mechanisms, and exposure routes and receptors. The text that follows, provides the rational for focusing the analysis on the specific receptors, exposure routes, and contaminant sources that produce the greatest potential contributions to human health risk.

A.3.2.1 Sources of Contamination

Areas 1 and 2 and the Ford property are considered as potential sources of contamination in this risk assessment and have been selected for the evaluation of risks to current and potential future receptors identified in the Operable Unit 1 conceptual model. The list of COPCs are found in

Tables A.2-2 and A.2-4 for Area 1; Tables A.2-3 and A.2-5 for Area 2; and Tables A.2-6 and A.2-7 for the Ford property.

A.3.2.1.1 Area 1

Surface and subsurface soils within Area 1 were sampled during the RI/FS sampling program to characterize the extent of contamination. Spatially, most of this contamination is localized into layers and covered with a layer of soil and landfill debris that varies in thickness. Some of these layers of contamination are partially exposed to the surface.

A.3.2.1.2 Area 2

Surface and subsurface soils within Area 2 were sampled as part of the same RI/FS field sampling program used to characterize Area 1. The contaminated materials in Area 2 are generally localized into an irregular layer overlaying construction debris and dirt. Part of this layer is covered with soil and construction debris; the remainder is exposed at the ground surface.

A.3.2.1.3 Ford Property

Surface and subsurface soils to the west of the landfill property were sampled to determine whether radionuclides had been released onto the surrounding soil. Slightly elevated concentrations of radionuclides were found along a narrow strip of land located on the eastern edge of the Ford property. Above-background concentrations of radionuclides were limited to surface soil in all but one borehole.

A.3.2.2 Potential Release Mechanisms

Chemicals may be released to the environment by a number of processes. These processes are referred to as "release mechanisms" in this report.

Release mechanisms at the West Lake Landfill have been identified by recognizing the potential interactions of the physical environment with the sources in Areas 1 and 2 and the Ford property. The five release mechanisms evaluated for Operable Unit 1 sources are discussed in the following paragraphs.

A.3.2.2.1 Resuspension of Dust

Surface soil particles containing contaminants can be picked up by winds passing over areas of exposed soil and become suspended for a time in air. Recent measurements of airborne particulates made by McLaren/Hart during RI/FS sampling indicate that resuspension of dust does not seem to be an active release mechanism on the West Lake Landfill at this time (EMSI

1997b). This release mechanism has been included in this assessment because the vegetative cover at the West Lake Landfill may decrease in the future, resulting in an increased potential for releases.

A.3.2.2.2 Volatilization of Organics

Volatile chemicals can escape directly from a solid matrix as a gas or vapor in a process called volatilization. Chemicals released in this manner mix with adjacent air and can move freely with the wind. This release mechanism is included for completeness, but because no volatile chemicals are identified as COPCs, this release mechanism will not be considered further.

A.3.2.2.3 Radon Emission

Radon is an inert gas that is generated by the decay of radium. Because it is a gas, radon produced in a soil matrix can potentially escape from the soil into the air above it. This is a common process that occurs in all soils, because all soils contain some radium. This release mechanism only becomes significant when radium concentrations in soil reach some critical level. This critical level depends on many factors including the type of soil, the grain size, and the presence of overlying soil. Radon emission has been included as a release mechanism in this risk assessment because the future radium concentration in the Area 1 and Area 2 source terms will increase from current levels as thorium-230 decays to radium-226.

A.3.2.2.4 Leaching

Soluble chemicals within a soil matrix can be dissolved by water percolating through the soil. These dissolved chemicals can then pass through the soil and enter the groundwater beneath the West Lake Landfill. The degree to which a radionuclide dissolves in water or remains sorbed to the soil matrix is described by the distribution coefficient, K_d, for the element or chemical. A distribution coefficient describes the partitioning of a chemical to soil and to water as the concentration in soil divided by the concentration in water. The higher the numerical value of the distribution coefficient of a chemical in a soil matrix the less soluble it is.

The leaching release mechanism was considered for inclusion in the risk assessment, but was rejected because literature studies (Thibault et al. 1990) indicate that the COPCs in the human health risk assessment that are expected to produce the vast majority of the radiation exposure from Operable Unit 1 (thorium-230, radium-226, protactinium-231) are relatively insoluble and thus are generally not subject to leaching. Distribution coefficients in sand, loam, and clay range from 3200 liters per kilogram (L/kg) to 5800 L/kg for thorium, 500 L/kg to 36000 L/kg for radium, and 550 L/kg to 2700 L/kg for protactinium (Sheppard and Thibault 1990). These

values indicate a strong tendency for adsorption/absorption of these radionucildes by the soil matrix. Section 7.0 of the RI provides discussion of the quality of perched and alluvial groundwater, based on sample analytical results, and the potential for migration of radionuclides by leaching in the future.

A.3.2.2.5 Soil Erosion by Surface Water

Chemicals in surface soil particles can be picked up and carried by flowing surface water during runoff events. This release mechanism was included in this risk assessment because RI/FS sampling indicates that ditches on the West Lake Landfill may contain some elevated concentrations of COPCs. In addition, the eastern edge of the Ford property contains above-background concentrations of radionuclides in surface soil. These radionuclides were most likely transported there by surface water runoff from Area 2.

A.3.2.3 Exposure Routes

A receptor can come into contact with COPCs in a variety of ways, generally as the result of a receptor's behavior or lifestyle that brings him/her into contact with a contaminated exposure medium. This assessment defines a route mechanism as a stylized description of the behavior that brings a receptor into contact with a contaminated medium.

An exposure route describes how a chemical may enter or affect the human body. Exposures are divided into two types: internal exposures and external exposures. Internal exposures occur when contaminants are introduced directly into the human body through inhalation, ingestion, and absorption across dermal surfaces. External exposures do not require physical contact and occur when a receptor is close to certain radioactive chemicals. Such exposures are considered only for gamma-emitting radionuclides and result in the irradiation of an individual by penetrating radiation from a radioactive source.

The remainder of this section describes the exposure routes evaluated in this assessment. The receptors evaluated for these exposure routes are described in Section A.3.2.4.

A.3.2.3.1 Exposures from Immersion in Air

This route assumes a receptor is immersed in air containing suspended particulates and gases, such as radon, originating in soil or waste. Subsequent exposures can occur via inhalation.

A.3.2.3.2 Exposures from Direct Contact with Soil, or Surface Water

Receptors may come into direct contact with contaminated soil, or surface water. During the receptors' period of contact, they may be exposed via inadvertent ingestion of a small amount of this material or through dermal contact with these contaminated media.

A.3.2.3.3 Direct Exposure to Radiation

Direct exposures from radioactive material can occur when a receptor is near a radioactive source. Physical contact with a contaminated exposure medium is not necessary for exposure to external radiation to occur. The magnitude of exposure is directly related to the distance of the receptor from the source. Exposures can be reduced when shielding, such as soil, is interposed between the receptor and the source of radioactivity.

A.3.2.4 Potential Receptors

Information about the current operation practices at the West Lake Landfill and both current and expected future land use around the West Lake Landfill was used to select the representative receptors considered in this risk assessment. This selection process first identified the group of generic receptor types thought to be typically associated with landfills (Section A.3.2.4.1). After this initial pool of generic receptors was established, a combination of criteria was used to focus the assessment on those receptor scenarios that combined reasonable land-use assumptions with the greatest potential for exposure at the West Lake Landfill. These criteria considered the receptor scenario's compatibility with current and expected future land use of the West Lake Landfill property and surrounding area (Section A.3.2.4.2), and the potential for a receptor to be exposed to materials or radiation from Operable Unit 1 (Section A.3.2.4.3).

A.3.2.4.1 Initial List of Receptors Considered

During the preliminary stages of this risk assessment, several generic receptor scenarios were considered as potential candidates for inclusion in the quantitative evaluation of risks from the landfill. These candidate receptor scenarios were drawn from the following groups:

Residents and Farmers: This group of receptors would live on the landfill or on adjacent property. They would raise some or all of their food themselves at the landfill.

Recreational Users and Transients: This group of receptors consists of people using the landfill for short periods of time. The recreational user would use the landfill for hiking. Transients, such as trespassers, would spend short periods of time on the landfill because the institutional controls limit their access to the landfill.

On-site and Off-site Workers: This group of receptors consists of people who spend a portion of

their time employed at the landfill (on-site) or adjacent to it (off-site). This includes both indoor and outdoor workers. Examples of workers include construction workers, grounds keepers, and commercial building users.

These groups of candidate receptor scenarios are the types of scenarios that might be found around a generic landfill operation. The receptor scenarios that might plausibly be expected in association with the West Lake Landfill are a subset of these more generic receptor scenarios. Table A.3-1 lists the candidate receptor scenarios considered to be plausible scenarios from the group of candidate receptor scenarios, and the final list of receptor scenarios selected for this assessment.

A.3.2.4.2 Compatibility with Surrounding Land Use

Each potential receptor scenario was first examined to determine its compatibility with current and expected future land use and access controls on the West Lake Landfill and adjacent properties. Areas 1 and 2 are located in an unused section of an operating landfill. The landfill is surrounded by industrial/commercial property. Casual access to the landfill is currently restricted with fences, signs, and periodic visual inspection. In addition, restrictive covenants (see Attachment A.II) prohibit residential use and construction of buildings at the West Lake Landfill.

Current Scenarios for Receptors within Operable Unit 1 Boundaries

Areas 1 and 2 are currently posted with radiation warning signs, and no grounds maintenance is performed within the boundaries of these areas. This combination of current land uses and existing access controls limits the number of current plausible receptor scenarios for Areas 1 and 2 to supervised remediation workers. Exposures to remediation workers will be evaluated during the short-term risk assessment conducted as part of the Feasibility Study, and are not considered further in this baseline risk assessment. Based on these observations and assumptions, no receptor scenarios were judged to be compatible with existing land-use practices and access controls within the boundaries of Areas 1 and 2 (Table A.3-1).

Current Receptor Scenarios within the West Lake Landfill and Adjacent to Operable Unit 1

Current plausible receptor scenarios for areas adjacent to Areas 1 and 2 are limited to on-site workers such as grounds keepers. Ground maintenance on this portion of the landfill is typically performed three times a year. A building housing office workers is currently located approximately 50 feet to the north of Area 1.

Based on this information, the grounds keeper and building user are the only receptor scenarios that are compatible with current land-use practices and access controls for these locations (Table A.3-1).

Current Receptor Scenarios on Property Surrounding the West Lake Landfill

The candidate receptor scenarios were compared to existing land-use practices and access controls on property near the landfill. The landfill is surrounded by industrial/commercial property. Examples of nearby land use include outdoor storage of roll-off boxes and trailer parking. Casual access to this area is also possible, but no permanent residences are located within approximately one-fourth mile of Areas 1 and 2. Based on these observations, plausible receptor scenarios for these locations include trespassers, grounds keepers, and storage yard workers (Table A.3-1).

Future Receptor Scenarios

Current land-use practices in the properties around the West Lake Landfill and covenant restrictions on the West Lake Landfill were used to forecast the future land-use practices on these properties. Residential land use and groundwater wells have been precluded at the West Lake Landfill (including Areas 1 and 2) by restrictive covenants (see Attachment A.II). Construction work, commercial and industrial uses, have also been precluded on Areas 1 and 2 by a Supplemental Declaration of Covenants and Restrictions recorded by Rock Road Industries, Inc. prohibiting the placement of buildings and restricting the installation of underground utilities, pipes and/or excavation upon the operable unit. This combination of land uses and covenant restrictions limits the number of future plausible receptor scenarios on Areas 1 and 2 to recreational users, trespassers, or on-site workers such as grounds keepers, workers in adjacent buildings who traverse Areas 1 and 2 when entering and leaving, and workers using the operable unit as an outdoor storage yard (Table A.3-1).

A.3.2.4.3 Receptors with Complete Exposure Pathways

The receptor scenarios judged to be compatible with current and future uses of the West Lake Landfill were then evaluated to determine if a plausible means of exposure existed.

Current Receptor Scenarios

The grounds keeper scenario for the West Lake Landfill (excluding Areas 1 and 2) has a complete exposure pathway. The grounds keeper scenario and the trespasser scenario for the Ford property have complete exposure pathways (Table A.3-1).

The only exposure route possible for the building user on the West Lake Landfill is inhalation of resuspended dust or radon. This route has been eliminated as a current exposure scenario based on negative results of air monitoring data and indoor radon measurement data collected by the landfill operator (McLaren/Hart 1996g, Golder 1996b). Therefore, the building user does not have a complete exposure pathway (Table A.3-1).

Future Receptor Scenarios

One or more plausible exposure pathways exist for the grounds keeper, recreational user, trespasser, commercial building user, construction worker, adjacent building user, and outdoor storage yard worker receptors that were found to be compatible with expected future land-use practices (Table A.3-1).

A.3.2.4.4 Final Selection Receptor Scenarios

In some cases, more than one plausible receptor scenario was identified for a given location and time period. To focus the assessment on the significant receptors and exposure routes, the remaining receptor scenarios were examined to determine which receptors had the greatest potential for exposure. Receptor scenarios were selected for quantitative evaluation that had the highest potential for exposure or had a critical population. These are indicated in Table A.3-1. If these receptor scenarios were associated with competing land uses, the receptor scenarios for the land use having the greatest exposure potential was selected for quantitative evaluation.

Current Receptor Scenarios within the West Lake Landfill and Adjacent to Operable Unit 1

Based on the analysis in Section A.3.2.4.2, the grounds keeper scenario was selected as the representative receptor scenario under current conditions at the West Lake Landfill.

Current Receptor Scenarios for the Ford Property

Both the grounds keeper scenario and the trespasser scenario incorporate the same kinds of exposures to similar concentrations and media. Comparing these two receptor scenarios, the grounds keeper would have a greater potential for exposure than the trespasser, because the grounds keeper would be exposed for longer periods of time than the trespasser. Therefore, the

grounds keeper scenario was selected as the representative receptor scenario under current conditions for the Ford property (Table A.3-1).

Future Receptor Scenarios on Areas 1 and 2

Five land-use scenarios are possible in light of the deed restriction discussed above and the industrial nature of the area. These include facility maintenance (grounds keeper), parking for an adjacent building, ancillary use such as the outdoor storage yard by an adjacent building user, recreational use and trespassing. The commercial/industrial development of land use in the vicinity will heavily influence any future use of Areas 1 and 2. Therefore, only worker, or occasional trespasser scenarios are considered to be realistic.

Future Receptor Scenarios for the Ford Property

The Ford property could be used as a commercial/industrial site in the future. Due to the comparatively low concentrations of COPCs in off-site media, radon emanation from the soil and into a building will not be a viable route. The building users' exposure to contaminated material on the Ford property would be further reduced by building structures. The construction worker, trespasser and grounds keeper scenarios all share common exposure routes and media concentrations. Comparing these three receptor scenarios, the grounds keeper would have the highest potential for exposure of the three, because the grounds keeper would be exposed for longer periods of time than the other potential receptors (Table A.3-1).

A.3.2.5 Exposure Scenario Descriptions

The hypothetical exposure scenarios selected for quantitative evaluation (Table A.3-1) as part of this assessment are described in the following sections. Each exposure scenario describes the type of receptor, the receptor's behavior, and the kinds of exposures postulated. The scenarios have been grouped into current and future scenarios.

A.3.2.5.1 Current Exposure Scenarios

The current exposure scenarios are hypothetical and are based on interviews at the West Lake Landfill and observations made during visits to the West Lake Landfill.

Current Exposure Scenario for the West Lake Landfill (Outside of Areas 1 and 2)

This scenario assumes industrial/occupational exposures of an individual employed as a grounds keeper at the West Lake Landfill (outside of Areas 1 and 2). The grounds keeper is assumed to

be an employee who brush hogs three days per year adjacent to Operable Unit 1. The exposure route for this receptor is external radiation exposure from contaminated soil.

Current Exposure Scenario for the Ford Property

This scenario assumes industrial/occupational exposures of an individual employed as a grounds keeper on the Ford property. The grounds keeper is assumed to be an employee who maintains fences, cuts grass, and performs outdoor maintenance on a regular basis (one day per week) through the growing season (26 weeks). Exposure routes for this receptor include:

- incidental ingestion of soil,
- dermal contact with COPCs in soil, and
- external radiation exposure from contaminated soil.

A.3.2.5.2 Future Exposure Scenarios

The future scenarios were developed by extrapolating current trends in local land use into the future.

Future Exposure Scenarios for Areas 1 and 2 of the West Lake Landfill

These scenarios assume industrial/occupational exposure of a grounds keeper, an adjacent building user in the parking area, and a storage yard worker on Areas 1 and 2. These scenarios assume no additional access controls are in place. The grounds keeper is assumed to be an employee who brush hogs in Areas 1 and 2 three days per year. Exposure routes for this receptor include:

- inhalation of fugitive dust and radon,
- incidental ingestion of soil,
- dermal contact with COPCs in soil, and
- external radiation exposure from contaminated soil.

The adjacent building user works in a building adjacent to Areas 1 and 2 and uses portions of these areas for parking. Exposure routes for this receptor include only external radiation exposure from contaminated soil beneath the paved or graveled parking lot on Areas 1 and 2. Exposure occurs briefly each day when the building user crosses the paved or gravel lot going to and from his or her vehicle. The outdoor storage yard worker works for seven hours per day in a building located adjacent to Areas 1 and 2 and works for one hour per day outdoors on the paved

or graveled area on Areas 1 and 2 performing duties related to the outdoor storage yard. Exposure routes for this receptor include only external radiation exposure from contaminated soil beneath the paved or gravel lot on Areas 1 and 2.

Future Exposure Scenario for the Ford Property

This scenario assumes industrial/occupational exposure to an individual employed as a grounds keeper on the Ford property. The grounds keeper is assumed to be an employee who maintains fences, cuts grass, and performs outdoor maintenance (grounds keeper) on a regular basis (one day per week). Exposure routes for this receptor include:

- inhalation of fugitive dust and radon,
- incidental ingestion of soil,
- dermal contact with COPCs in soil, and
- external radiation exposure from contaminated soil.

A.3.2.5.3 Summary of Selected Exposure Pathways

Table A.3-1 presents a summary of the potential exposure pathways presented in the conceptual model in Figure A.3-1. These land uses and routes comprise the complete pathways that will be carried through the quantitative risk assessment for each identified receptor.

A.3.3 EXPOSURE POINT CONCENTRATIONS

The exposure point concentration is the concentration of a contaminant in an exposure medium that may be contacted by a real or hypothetical receptor. Determination of the exposure point concentration depends on several factors, including:

- Availability of validated data for COPCs,
- Amount of data available to perform statistical analysis for a particular data set,
- Background concentrations not attributed to the West Lake Landfill, and
- Location of the potential receptor.

For the evaluation of current (baseline) land use/site conditions, exposure concentrations for Operable Unit 1 are determined using available analytical data. To be consistent with the concept of the Reasonable Maximum Exposure (RME) (EPA 1989a), an estimate of the highest

exposure that can reasonably be expected to occur requires a reasonable maximum estimate of the concentration of each contaminant in each exposure medium.

Because of the uncertainty associated with any estimate of chemical concentration, the upper 95 percent confidence limit (95% UCL) on the arithmetic mean is used to represent concentrations of COPCs in environmental media. The equation of the 95% UCL is presented below:

$$UCL = \overline{X} + t_{1-\alpha,n-1} \bullet (s/\sqrt{n}) \qquad \text{Eq. A.3-1}$$

where:

$\overline{X}$	=	sample arithmetic mean
$t_{1-\alpha, n-1}$	=	critical value for Student's t-Distribution (Helsel and Hirsch 1992, Sokal and Rohlf 1981, Gilbert 1987)
α	=	significance level of 0.05
s	=	sample standard deviation, and
n	=	sample size

Calculation of the 95% UCL for each COPC was performed using the analytical results presented in the McLaren/Hart Soil Boring/Surface Soil Investigation Report (McLaren/Hart 1996b), analytical results from a supplemental soil sampling effort conducted at the Ford property by EMSI (EMSI 1997c) (used in previous drafts of the risk assessment), and analytical results from a recharacterization soil sampling effort conducted at the Ford property by Herst and Associates (Herst 2000) (used in this draft of the risk assessment). For sample results reported as less than the minimum detectable activity concentration (MDA) of the analytical procedure, one-half of the respective MDA value was used in the calculation.

A.3.3.1 Current Exposure Point Concentrations in Soil

Tables A.3-2 through A.3-4 present the exposure point soil concentrations used to assess risks to hypothetical receptors under current source-term and land-use conditions. Some of the series radionuclides listed in these tables are known to be in equilibrium (equal concentrations) with their shorter-lived daughter products. These series nuclides are listed with the designation "+ dtrs" following the name of the radionuclide. This designation indicates that the exposures assessed from this series radionuclide also include the contributions of its short-lived daughters. For example the "U-238 + 2 dtrs" entry indicates that the exposures assessed for uranium-238 include the contributions from two short-lived daughter radionuclides - thorium-234 and protactinium-234m.

A.3.3.2 Future Exposure Point Concentrations in Soil

The concentrations of the radiological chemicals in the source term are expected to change over the course of the 1000-year study period due to radiological decay and ingrowth[1]. The concentration of radium-226 will increase as its parent radionuclide, thorium-230, decays. The concentration of lead-210 in the soil will increase to equal the radium-226 activity. Because of this equilibration, exposure for "Pb-210 + 2 dtrs" has been included in the total exposure for "Ra-226 + 8 dtrs". These changes are reflected in the future exposure point concentrations presented in Tables A.3-5 through A.3-7. These future exposure point concentrations were used to assess risks to hypothetical receptors under future source-term and land-use conditions.

The soil data have been grouped into surface soil and all soil depths. This segregation of data permits the evaluation of exposures from the different soil depths. For example, the future grounds keeper scenario includes the assumption of casual exposure to soil during occupational activities. Potential exposures of the future grounds keeper were therefore assessed using surface soil concentrations for incidental ingestion and inhalation of particulates; concentrations for all soil depths were used for assessing potential exposures from radon and external radiation.

A.3.3.3 Future Exposure Point Concentrations In Air

Current measurements indicate that resuspension of soil at the West Lake Landfill is not a viable current release mechanism. This may change in the future if the amount of vegetation on the West Lake Landfill decreases. To reflect this possibility, a simple resuspension model was used to calculate future air concentrations from resuspended dust. This model is based on two assumptions:

1) Nominal dust loading in air at a humid site is 50 $\mu g/m^3$ (NCRP 1984), and
2) All of the dust in the air is resuspended surface soil from the area of interest.

This model was used to calculate the concentrations of particulates in Table A.3-8.

Radon concentrations in outdoor air were calculated using the radon transport model RAECOM (NRC 1984). Exposure to airborne radon and its short-lived daughters was calculated and included in the inhalation exposure route.

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[1] A 1000-year study period was selected as relevant and appropriate based on design requirements of 10CFR61 and 40CFR192.

A.3.4 QUANTIFICATION OF EXPOSURE

Estimates of exposure are based on the chemical concentration at the exposure points (described in Section A.3.3) and scenario-specific assumptions and intake parameters. The equations used to quantify intakes have been obtained from EPA risk assessment guidance (EPA 1989a, 1992b, 1997b, and 1997c).

The method used to quantify chronic exposures in this assessment employs the concept of the RME. The RME is the maximum exposure reasonably expected to occur at the West Lake Landfill (EPA 1989a). If the RME is determined to be acceptable, then it is likely that all other lesser exposures at the West Lake Landfill will also be acceptable.

Exposure model parameters used in the Operable Unit 1 risk assessment are presented in Table A.3-9 for selected receptors. All parameter values were extracted from EPA Risk assessment guidance documents unless noted otherwise.

This section presents the equations used to quantify the magnitude of exposures expected to result from all reasonable exposure pathways at the West Lake Landfill. The exposure routes are reasonable in light of the current and anticipated future land-use scenarios and to the concentrations of COPCs determined for the environmental media. Exposures are quantified using a set of equations and parameters that are unique to each exposure pathway. The exposure assessment process results in calculated daily intakes expressed as milligrams of chemical per kilogram of body weight per day (mg/kg-day) for hazardous chemicals and as pCi per lifetime for radionuclides. Exposures to external radiation are calculated separately from intake calculations.

A.3.4.1 Equations Quantifying Intakes and Exposures to Soil

Exposure routes for exposure to soils include incidental ingestion, dermal contact, and direct irradiation. Sections A.3.4.1.1 and A.3.4.1.3 present the equations used to calculate intake from these exposures.

A.3.4.1.1 Incidental Ingestion of Soil

The estimation of intake of chemicals in soil is determined using the concentration in the soil at the location of interest. Evaluation of the soil ingestion route is performed using Equations A.3-2 and A.3-3 (EPA 1989a):

$$(radionuclides)\ I_{si} = (C_{si})(IR)(ED)(EF)(FI) \qquad \text{Eq. A.3-2}$$

$$(chemicals)\ I_{si} = \frac{(C_{si})(IR)(CF)(FI)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. A.3-3}$$

where:

I_{si}	=	intake from soil for i^{th} chemical (pCi, rad) (mg/kg-d, chem)
C_{si}	=	concentration of i^{th} chemical in soil (pCi/g, rad) (mg/kg, chem)
IR	=	ingestion rate (g/d, rad) (g/d, chem)
CF	=	conversion factor (10^{-3} kg/g, chem)
ED	=	exposure duration (y)
EF	=	exposure frequency (d/y)
FI	=	fraction ingested from source being evaluated (unitless)
BW	=	body weight (kg)
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (75 y) (365 d/y)

A.3.4.1.2 Dermal Contact with Soil

The estimation of intake of organic chemicals in soil via absorption through the skin is determined using the concentration in the soil at the location evaluated. The amount of a chemical taken into the body upon exposure via dermal contact with soil is referred to as an absorbed dose. Dermal absorption is calculated using Equation A.3-4:

$$DAD_s = \frac{(C_{si})(CF)(SA)(AF)(ABS)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. A.3-4}$$

where:

DAD_s = dermally absorbed dose from contact with soil (mg/kg-day)
C_{si} = concentration of i^{th} chemical in soil (mg/kg)
SA = skin surface area available for contact (cm^2/d)
AF = skin adherence factor (mg/cm^2)
ABS = dermal absorption factor (unitless)
CF = conversion factor; (10^{-6} kg/mg)
EF = exposure frequency (d/y)
ED = exposure duration (y)
BW = body weight (kg)
AT = averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (75 y) (365 d/y)

The dermal permeability constants were obtained from the EPA's *Dermal Exposure Assessment: Principles and Applications* (EPA 1992c).

A.3.4.1.3 Direct Radiation Exposure from Bare Soil

Direct radiation exposure from radionuclides in soil does not involve intake of the radionuclide (or soil). Rather, the external radiation exposure is proportional to the concentration of gamma-emitting radionuclides in the soil and on the total time the individual is exposed to the soil. The estimation of direct radiation exposure from soil is determined using Equation A.3-5.

$$A = (C_{si})(ED)(EF)(CF)\left[ET_{in}(1 - S_i) + ET_{out}\, x\, (1 - S_o)\right] \qquad \text{Eq. A.3-5}$$

where:

A = time integrated radioactivity concentration (pCi-yr/g)
C_{si} = concentration of i^{th} chemical in surface soil (pCi/g)
ED = exposure duration (y) years
EF = exposure frequency (d/y)
CF = 1.142×10^{-4} y/h
ET_{in} = exposure time indoors on site (h/d)
ET_{out} = exposure time outdoors on site (h/d)
S_i = indoor shielding factor
S_o = outdoor shielding factor

Equation A.3-5 does not yield a calculation of radiation exposure in the strict definition of the term, but rather, the equation yields a quantity that may be described as the total activity encountered by the receptor during the study period. It is analogous to the total activity ingested by an individual during the study period.

A.3.4.1.4 Equations Quantifying Intakes and Exposures from Inhalation

The amount of a chemical a receptor takes in as a result of respiration is determined using the concentration of a chemical in the air. Equations A.3-6 and A.3-7 are used to quantify intake from the inhalation route:

$$(radionuclides)\ I_{ai} = (C_{ai})(IR)(ET)(EF)(ED) \qquad \text{Eq. A.3-6}$$

$$(chemicals)\ I_{ai} = \frac{(C_{ai})(CF)(IR)(ET)(EF)(ED)}{(BW)(AT)} \qquad \text{Eq. A.3-7}$$

where:

I_{ai}	=	intake from inhalation (pCi, rad) (mg/kg-d, chemical)
C_{ai}	=	concentration of i^{th} chemical in air (pCi/m^3, rad) (µg/m^3, chemical)
CF	=	conversion factor; (10^{-3} mg/µg)
IR	=	inhalation rate (m^3/h)
ET	=	exposure time (h/d)
EF	=	exposure frequency (d/y)
ED	=	exposure duration (y)
BW	=	body weight (kg); and
AT	=	averaging time (d); for noncarcinogens, AT equals (ED) (365 d/y); for chemical carcinogens, AT equals (75 y) (365 d/y)

A.3.4.1.5 Quantification of Intakes and Exposures from Multiple Pathways

The most probable scenarios involve simultaneous exposures via a number of pathways. Exposures via multiple exposure pathways are evaluated by assuming the contributions from component pathways are additive. Thus, all the receptors assumed to be exposed to more than one exposure pathway have been evaluated accordingly.

A.3.4.2 Scenario-Specific Assumptions and Exposure Parameters

Exposure parameters are dependent on receptor-specific behavior patterns and vary from receptor scenario to receptor scenario. The following sections begin with a brief description of each set of parameters used to evaluate exposures to hypothetical receptors during this assessment. This synopsis is followed by descriptions of any site-specific parameter values and their derivation. Table A.3-9 contains a summary of these parameters.

A.3.4.2.1 Exposure Duration (ED)

The exposure duration is the period of time a receptor is exposed in a lifetime. The median time a worker remains in one job is 6.6 years (EPA 1997b). This value has been selected as the exposure duration for each of the grounds keeper scenarios, the adjacent building user scenario, and the storage yard worker scenario.

A.3.4.2.2 Exposure Frequency (EF)

The exposure frequency is the number of days a receptor is exposed each year. The grounds keeper is assumed to perform some caretaking or maintenance task for 3 days/yr on areas within the West Lake Landfill and 26 days/yr on the Ford Property. The adjacent building user and the storage yard worker are assumed to be present 250 days/yr on areas within the West Lake Landfill.

A.3.4.2.3 Exposure Time (ET)

The exposure time is the postulated number of hours each day a receptor is exposed. The exposure times used in this report differ for each receptor.

The grounds keeper on the landfill is assumed to work outdoors with powered brush hogging equipment for 8 hr/day on areas within the West Lake Landfill. This is based on interviews with the site staff. The grounds keeper on the Ford property is assumed to spend 2 hr/day on the Ford property as part of a lawn care team that uses powered grass cutting and trimming equipment.

The adjacent building user is assumed to be outdoors only briefly while walking between their vehicle and the adjacent building each day (0.1 hr/day), and is assumed to be inside and adjacent building for an 8-hour work day.

The storage yard worker exposure time is based on observations of activities on nearby property that is used for roll-off container storage and trailer parking. The time spent by workers loading and unloading roll-off containers or attaching or dropping trailers is relatively short. Based on

these observations, the storage yard worker is assumed to work outdoors in Areas 1 and 2 for one hour per day and is assumed to work indoors in an adjacent building, or in other portions of the landfill outside of Areas 1 and 2, for 7 hours per day.

A.3.4.2.4 Inhalation Rates (IR)

The inhalation rate is the volume of air inhaled daily by a receptor. EPA suggests using a value of 1.3 cubic meters per hour (m^3/hr) for adults involved with outdoor activities (EPA 1997b). This value has been selected as the inhalation rate for each receptor.

A.3.4.2.5 Soil Ingestion Rates (IR)

The soil ingestion rate is the mass of soil ingested daily by a receptor. This ingestion rate is influenced by the types of activities a receptor typically performs during the course of a day. OSWER Directive 9285.6-03, Human Health Evaluation Manual, Supplemental Guidance: "Standard Default Exposure Factors" (1991) recommended an occupational intake of 50 mg/d (pp. 9-10 and Table 1). It also contains a provision to use 480 mg/d for occupations involving earthmoving such as construction or landscaping (Appendix B). The likely receptor on this site will not be routinely moving dirt because such activities are prohibited by legal restrictions on property use.

It was judged that the 50 mg/d stipulated by OSWER Directive 9285.6-03 might not be sufficiently conservative. This judgement was made because resuspended dirt may settle on a grounds keeper's skin, increasing the potential to ingest additional amounts of soil. Once the determination was made that the standard default parameter may not be sufficiently conservative for this specific site, information on soil ingestion and pica among adults presented on page 4-21 of the August 1997 Exposure Factors Handbook was used to select a more health protective value for this parameter.

On page 4-21 of this the August 1997 Exposure Factors Handbook, EPA discusses three soil ingestion studies. After evaluating the information available, EPA opines that the results of the tracer study published by Calabrese, et al., in 1990 are " probably the most reliable of the three..." The EPA summary states this study "...found a range of 30 to 100 mg/day..." for adults. The ingestion rate of 100 mg/d (0.0001 kg/d) is chosen for this risk assessment and is the maximum adult ingestion rate reported by the 1990 study by Calabrese, et al. (EPA 1997b). This soil ingestion rate is used for each receptor.

A.3.4.2.6 Fraction of Ingestion (FI)

Only part of the soil ingested during a typical day will be ingested while working at Areas 1 and 2 of the West Lake Landfill. However, this assessment makes the health-protective assumption that the soil ingested was all from the operable unit, yielding an FI of 1 for each receptor.

A.3.4.2.7 Body Weight (BW)

The body weight is the mass of the receptor, in kilograms. This assessment uses the median body weight of 71.8 kilograms for each receptor (EPA 1997b).

A.3.4.2.8 Surface Area (SA)

The surface area is the amount of the body skin surface that is exposed as a result of a specific activity or group of activities. EPA's interim report on dermal assessment (EPA 1992b) and supplemental guidance on dermal assessment (EPA 1992c) lists suggested values for surface areas. This has been clarified in the latest revision of the Exposure Factors Handbook (EPA 1997b). The surface areas used to evaluate exposures from dermal contact with dirt are dependent on the body parts in contact with the soil. The tables in the Exposure Factors Handbook (EPA 1997b) were used to calculate a 95% confidence level surface area of 0.92 m^2 for exposed body parts (head, legs, hands, and arms). This parameter applies only to the grounds keeper receptor because the dermal contact pathway is not complete for the adjacent building user and the storage yard worker due to their presence on a paved or graveled lot.

A.3.4.2.9 Adherence Factor (AF)

Uptake of chemicals through the skin from soil requires that a sufficiently intimate intake be established between the soil and the skin. One of the factors that determines the quantity of chemical absorbed is the amount of soil that adheres to the skin.

The adherence factor was developed in four steps using guidance and recommendations provided in Chapter of EPA's Exposure Factors Handbook, August 1997 (EFH).

The types of exposed body parts were first determined. For the grounds keeper, this was done by examining the types of clothing worn by grounds keepers listed in EFH Table 6-11, "Summary of Field Studies". Five grounds keeper descriptions are presented in EFH Table 6-11, and Grounds keeper 5 was selected because they were active for 8 hours each day, and their clothing resulted in the most exposed surface area of all the grounds keepers. Exposed body parts for the grounds keeper wearing shorts, a short sleeve shirt, and work boots were determined to be the head, arms, hands, and legs.

The surface area of the head, arms, hands, and legs were next determined. The surface areas used in this report are the weighted averages for each body part listed for men and women in EFH Table 6-4. The total exposed surface area for the grounds keeper is 0.92 m^2 using this method.

Once the body parts and receptor activities were determined, Table 6-12 of the EFH was used to determine the soil adherence factor of the exposed body parts. These adherence factors range from 0.0009 to 0.032 mg/cm^2.

The surface areas and the adherence factors were then used to construct a weighted average adherence factor. For the grounds keeper, the adherence factor was calculated to be 0.007 mg/cm^2. This parameter applies only to the grounds keeper receptor because the dermal contact pathway is not complete for the adjacent building user and the storage yard worker due to their presence on a paved or graveled lot.

A.3.4.2.10 Averaging Time (AT)

The averaging time is the duration of time, expressed in days, over which the period of exposure occurs. It is only used in the evaluation of chemical exposures. The averaging time selected depends on the health effect being evaluated. Long-term intakes of noncarcinogenic agents are calculated by averaging intakes over the period of exposure (the exposure duration of 6.6 years in this risk assessment), in accordance with EPA guidance (EPA 1989a). Carcinogenic intakes are averaged over the lifetime of the receptor (27,375 days). This approach is based on the contention that a high dose administered over a short period is equivalent to a low dose over a long period.

A.3.4.2.11 Indoor and Outdoor Shielding Factors (S)

The indoor shielding factor accounts for the reduction in direct radiation exposure provided by the structure of a building while the receptor is indoors. This parameter does not apply to the grounds keepers. The value selected for the adjacent building user and the storage yard worker is one (1), resulting in no direct radiation exposure while indoors.

The outdoor shielding factor accounts for the reduction in direct radiation exposure provided by a paved or graveled parking lot/storage yard while the receptor is outdoors on those areas. This shielding factor is based on the assumption that the areas evaluated will have to be covered with 6 to 10 inches of gravel and or pavement to provide all-weather access as a parking or storage

facility. A series of Microshield[2] runs was performed to determine the degree of shielding this amount of cover would provide from radium-226 and its daughters. It was found that at least 80% of the radioactivity would be attenuated by the paving material. The shielding factor selected for the adjacent building user and the storage yard worker is 0.8 resulting in a reduction in the direct radiation exposure to 20% (one fifth) of the unshielded exposure while the receptor is outdoors on the parking lot/storage yard. This parameter does not apply to the grounds keepers.

A.3.5 Results of Exposure Assessment

This exposure assessment evaluates the types and magnitudes of contact that a potential receptor may have with site-related chemicals. This postulated contact, either through ingestion, inhalation or absorption results in an intake of some quantity of the chemical by the hypothetical receptor. These intakes have been calculated using the methods, parameters, and concentrations described in this section. Intakes evaluated for each receptor scenario are presented in Tables A.3-10 through A.3-17.

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2 Microshield 4.20 is a standard, well accepted computer code designed to calculate radiation exposure rates from a variety of sources and shielding configurations (Grove Engineering, 1994).

Table A.3-1 Summary of Potential Exposure Pathways

		Receptor	Consistent with Land Use	Exposure Route					Selected for Quantitative Evaluation
				Inhalation Fugitive Dust	Inhalation of Radon	Incidental Ingestion	Dermal Contact	Direct Radiation	
Current Conditions	Operable Unit 1	Farm	No						
		Residence	No						
		Commercial Building User	No						
		Construction Worker	No						
		Recreational User	No						
		Grounds Keeper	No						
		Trespasser	No						
	West Lake Landfill (excluding Areas 1 & 2)	Farm	No						
		Residence	No						
		Commercial Building User	Yes	1	1				
		Construction Worker	No						
		Grounds Keeper	Yes	1	1			•	**Yes**
		Trespasser	No						
		Recreational User	No						
	Ford Property	Farm	No						
		Residence	No						
		Commercial Building User	No						
		Construction Worker	No						
		Storage Yard Worker	Yes	2	2	2	2	•	2, 3
		Grounds Keeper	Yes	1	•	•	•	•	**Yes**
		Trespasser	Yes	1	•	•	•	•	3
		Recreational User	No						
Future Conditions	Operable Unit 1	Farm	No						
		Residence	No						
		Storage Yard Worker	Yes	2	2	2	2	•	**Yes**
		Adjacent Building User	Yes	2	2	2	2	• 4	**Yes**
		Construction Worker	No						
		Grounds Keeper	Yes	•	•	•	•	•	**Yes**
		Recreational User	Yes	•	•	•	•	•	3
		Trespasser	Yes	•	•	•	•	•	3
	Ford Property	Farm	No						
		Residence	No						
		Storage Yard Worker	Yes	2	2	2	2	•	3
		Commercial Building User	Yes	2	2	2	2	• 4	3
		Construction Worker	Yes	•	•	•	•	•	3
		Grounds Keeper	Yes	•	•	•	•	•	**Yes**
		Recreational User	Yes	•	•	•	•	•	3
		Trespasser	Yes	•	•	•	•	•	3

Receptors in bold print indicate those receptors selected for quantitative evaluation.

• Indicates plausible use or existing pathway.

▩ A shaded box indicates that the receptor/exposure route combination was not selected because of land use conditions and or deed restrictions.

1 Data indicate that this release mechanism and exposure pathway do not exist.

2 Operable unit is assumed to be paved to allow these uses.

3 Other receptors in this land use have higher intake/exposure rates or longer exposure times.

4 Only when visiting parking lot.

Table A.3-2 Current Exposure Point Concentrations in Area 1 Soil

Analyte	95% CL on the Arithmetic Mean		Units
	Surface Soil	All Depths	
Uranium Series			
Uranium-238 + 2 dtrs	118	16.6	pCi/g
Uranium-234	122	16.9	pCi/g
Thorium-230	8140	1060	pCi/g
Radium-226 + 5 dtrs	581	71.6	pCi/g
Lead-210 + 2 dtrs	680	88.6	pCi/g
Actinium Series			
Uranium-235 + 1 dtr	5.99 [a]	0.84 [a]	pCi/g
Protactinium-231 + 8 dtrs	365	47.3	pCi/g
Thorium Series			
Thorium-232 + 10 dtrs	25.8	4.14	pCi/g
Inorganic Chemicals			
Arsenic	139	NE[b]	mg/kg
Organic Chemicals			
Aroclor-1254	0.70	0.48	mg/kg

[a] Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium. See the discussion in Section A.2.2.1.

[b] "NE" indicates no exposure because the receptor is not exposed to subsurface soil.

Table A.3-3 Current Exposure Point Concentrations in Area 2 Soil

Analyte	95% CL on the Arithmetic Mean		Units
	Surface Soil	All Depths	
Uranium Series			
Uranium-238 + 2 dtrs	83.5	27.1	pCi/g
Uranium-234	156	46.0	pCi/g
Thorium-230	8920	3730	pCi/g
Radium-226 + 5 dtrs	1130	338	pCi/g
Lead-210 + 2 dtrs	384	128	pCi/g
Actinium Series			
Uranium-235 + 1 dtr	5.99 [a]	1.83 [a]	pCi/g
Protactinium-231 + 8 dtrs	559	162	pCi/g
Thorium Series			
Thorium-232 + 10 dtrs	36.6	15.9	pCi/g
Inorganic Chemicals			
Arsenic	15.9	NE[b]	mg/kg
Lead	1176	NE	mg/kg
Uranium	250 [c]	NE	mg/kg
Organic Chemicals			
Aroclor-1254	1.02	NE	mg/kg

[a] Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium. See the discussion in Section A.2.2.1.

[b] "NE" indicates no exposure because the receptor is not exposed to subsurface soil.

[c] The uranium-238 isotope accounts for more than 99 percent of the mass of natural uranium. The mass concentration of uranium was calculated by dividing the uranium-238 activity in picocuries per gram (pCi/g) by its specific activity of 0.336 pCi/µg, resulting in a mass concentration of mg uranium per kg soil (mg/kg).

Table A.3-4 Current Exposure Point Concentrations for Ford Property Soil

Analyte	95% CL on the Arithmetic Mean	
	Surface Soil	Units
Uranium Series		
Uranium-238 + 2 dtrs	0.997	pCi/g
Uranium-234	1.01	pCi/g
Thorium-230	15	pCi/g
Radium-226 + 5 dtrs	1.08	pCi/g
Lead-210 + 2 dtrs	4.22	pCi/g
Actinium Series		
Uranium-235 + 1 dtr	0.050 [a]	pCi/g
Thorium Series		
Thorium-232 + 10 dtrs	1.40	pCi/g

[a] Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium. See the discussion in Section A.2.2.1.

Table A.3-5 Future Exposure Point Concentrations for Area 1 Soil

Analyte	95% CL on the Arithmetic Mean		Units
	Surface Soil	All Depths	
Uranium Series			
Uranium-238 + 2 dtrs	118	16.6	pCi/g
Uranium-234	122	16.9	pCi/g
Thorium-230	8140	1060	pCi/g
Radium-226 + 8 dtrs	3224	417	pCi/g
Actinium Series			
Uranium-235 + 1 dtr	5.99 [a]	0.84 [a]	pCi/g
Protactinium-231 + 8 dtrs	365	47.3	pCi/g
Thorium Series			
Thorium-232 + 10 dtrs	25.8	4.14	pCi/g
Inorganic Chemicals			
Arsenic	139	NE[b]	mg/kg
Organic Chemicals			
Aroclor-1254	0.70	0.48	mg/kg

[a] Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium. See the discussion in Section A.2.2.1.

[b] "NE" indicates no exposure because the receptor is not exposed to subsurface soil.

Table A.3-6 Future Exposure Point Concentrations for Area 2 Soil

Analyte	95% CL on the Arithmetic Mean		Units
	Surface Soil	All Depths	
Uranium Series			
Uranium-238 + 2 dtrs	83.5	27.1	pCi/g
Uranium-234	156	46.0	pCi/g
Thorium-230	8920	3730	pCi/g
Radium-226 + 8 dtrs	3853	1524	pCi/g
Actinium Series			
Uranium-235 + 1 dtr	5.99 [a]	1.83 [a]	pCi/g
Protactinium-231 + 8 dtrs	559	162	pCi/g
Thorium Series			
Thorium-232 + 10 dtrs	36.6	15.9	pCi/g
Inorganic Chemicals			
Arsenic	15.9	NE[b]	mg/kg
Lead	1176	NE	mg/kg
Uranium	250 [c]	NE	mg/kg
Organic Chemicals			
Aroclor-1254	1.02	NE	mg/kg

[a] Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundance in natural uranium. See the discussion in Section A.2.2.1.

[b] "NE" indicates no exposure because the receptor is not exposed to subsurface soil.

[c] Of the isotopes of natural uranium, uranium-238 accounts for more than 99 percent of the mass of uranium. The mass concentration of uranium was calculated by dividing the uranium-238 result in picocuries per gram (pCi/g) by the specific activity of 0.336 pCi/μg, resulting in a mass concentration of mg uranium per kg soil (mg/kg).

Table A.3-7 Future Exposure Point Concentrations for Ford Property Soil

	95% CL on the Arithmetic Mean	
Analyte	**Surface Soil**	**Units**
Uranium Series		
Uranium-238 + 2 dtrs	0.997	pCi/g
Uranium-234	1.01	pCi/g
Thorium-230	15	pCi/g
Radium-226 + 8 dtrs	5.95	pCi/g
Actinium Series		
Uranium-235 + 1 dtr	0.050 [a]	pCi/g
Thorium Series		
Thorium-232 + 10 dtrs	1.40	pCi/g

[a] Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundances in natural uranium. See the discussion in Section A.2.2.1.

Table A.3-8 Future Exposure Point Concentrations in Air

Analyte	95% Confidence Limit on the Arithmetic Mean of Surface Soil x Mass Loading Factor of 50 µg/m³			Units
	Area 1	Area 2	Ford Property	
Uranium Series				
Uranium-238 + 2 dtrs	5.89 E-3	4.18 E-3	4.99 E-5	pCi/m³
Uranium-234	6.10 E-3	7.80 E-3	5.03 E-5	pCi/m³
Thorium-230	4.07 E-1	4.46 E-1	7.50 E-4	pCi/m³
Radium-226 + 8 dtrs	1.61 E-1	1.93 E-1	2.97 E-4	pCi/m³
Radon-222	1.89 E+1 [a]	6.67 E+1 [a]	3.98 E-2 [a]	pCi/m³
Actinium Series				
Uranium-235 + 1 dtr	3.00 E-4 [b]	2.99 E-4 [b]	2.50 E-6 [b]	pCi/m³
Thorium Series				
Thorium-232 + 10 dtrs	1.29 E-3	1.83 E-3	7.00 E-5	pCi/m³
Inorganic Chemicals				
Arsenic	6.97 E-3	7.93 E-4	NA[c]	µg/m³
Lead	NA	5.88 E-2	NA	µg/m³
Uranium	NA	1.25 E-2	NA	µg/m³
Organic Chemicals				
Aroclor-1254	3.48E-05	5.10E-05	NA	µg/m³

[a] Calculated from the predicted radium-226 concentrations in soil using RAECOM (see Attachment A.I for details).

[b] Calculated using the uranium-238 and uranium-234 results and the expected isotopic abundances in natural uranium. See the discussion in Section A.2.2.1.

[c] "ND" indicates the radionuclide was not detected.

[d] "NA" indicates not applicable. Preliminary screening removed the chemical from consideration in this area.

Table A.3-9 Parameters Used to Estimate Potential Exposure

Pathway Parameter (units)	Current Hypothetical Receptors				Future Hypothetical Receptors							
	Ford Property Grounds Keeper Age 19+		Landfill Grounds Keeper Age 19+		Ford Property Grounds Keeper Age 19+		Landfill Grounds Keeper Age 19+		Adjacent Building User Age 19+		Storage Yard Worker Age 19+	
Scenario specific parameters												
ET indoors (h/d)	0	a	0	b	0	a	0	c	8	e	7	f
ET outdoors (h/d)	2	a	8	b	2	a	8	c	0.1	e	1	f
EF (d/y)	26	a	3	b	26	a	3	c	250	g	250	g
ED (y)	6.6	h	6.6	h	6.6	h	6.6	h	6.6	h	6.6	h
BW (kg)	71.8	i	71.8	i	71.8	i	71.8	i	71.8	i	71.8	i
Life (y)	75	j	75	j	75	j	75	j	75	j	75	j
AT-Noncancer (d)	2409	k	2409	k	2409	k	2409	k	2409	k	2409	k
AT-Cancer (d)	27375	k	27375	k	27375	k	27375	k	27375	k	27375	k
Inhalation of dusts, volatiles, and radon												
IR (m^3/h)	1.3	l	1.3	l	1.3	l	1.3	l	1.3	l	1.3	l
Incidental ingestion of soil/sediment												
IR (kg/d)	0.0001		0.0001	m	0.0001		0.0001		0	n	0	n
FI	1.00	o	1.00	o	1.00	o	1.00	o	1.00	o	1.00	o
Dermal contact with soil/sediment												
SA (cm^2)	9172	p	9172	p	9172	p	9172	p	0	n	0	n
AF (mg/cm^2)	0.00703	p	0.00703	p	0.00703	p	0.00703	p	0	n	0	n
ABS (unitless)	csv	q	csv	q	csv	q	csv	q	csv	q	csv	q

a - It is assumed that a lawn care crew can service areas adjacent to the Landfill on a regular basis. This assessment assumes an individual crew member works outdoors for 2 hours a day, one day a week during a 26-week growing season.
b - Currently, the grounds crew at the landfill will brush-hog OU1 three times a year as part of regular landfill closure maintenance. Brush-hogging on OU1 actually takes a fraction of a day to complete, but this assessment makes the health-protective assumption that this activity would take 8 hours to complete.
c - In the future, it is assumed that the current activity patterns of the grouns crew will continue.
e - Assumes an office worker would be in the building 8 hours a day, and would spend 0.5 h/week going to and from a car parked in the parking lot.
f - Assumes a lot worker spends 1 h/d working outside on a paved section of the Operable Unit. The remainder of the time is spent in an adjacent building.
g - Assumes office and lot workers spend 250 d/y working on or adjacent to the Operable Unit.
h - The median time a worker remains in one job is 6.6 years in EPA's Exposure Factors Handbook (EPA 1997b, pg 15 -17).
i - Recommended value of adult body weight on pg 7-10 of EPA's Exposure Factors Handbook (EPA 1997b).
j - Recommended value of life expectancy on pg 1-8 of EPA's Exposure Factors Handbook (EPA 1997b).
k - AT is 365 d/y * ED (y) for noncarcinogens, 365 d/y * 75 y life expectancy for carcinogens.
l - Average inhalation rate of outdoor worker in EPA's Exposure Factors Handbook (EPA 1997b, pg 5-24).
m - High end of the range of the adult soil ingestion rates reported by Calabrese, as cited in EPA's Exposure Factors Handbook (EPA 1997b, pg. 4-21).
n - The parking lot is assumed to be paved, so no soil ingestion or dermal contact is considered.
o - Typically FI = ET/time at site (8 h/d), however this assessment makes the health-protective assumption that FI = 8/8 for each receptor.
p - 95% values calcuated using the approach recommended on pages 6-8 and 6-9 of EPA 1997b and information provided on pages 6-8, 6-9, 6-14, and 6-20 to 6-23.
q - Chemical specific values: Aroclor-1254 = 6.0E-2, Arsenic = 3.2E-2, Lead = 1.0E-2, Uranium = 1.0E-2.

Table A.3-10 Calculated Intakes for Current Ford Property Grounds Keeper Scenario

Constituent	Exposure Route			Units
	Soil Ingestion	Inhalation	Dermal Absorption	
URANIUM SERIES				
Uranium-238 + 2 dtrs	1.7 E+1	NE[a]	NE	pCi
Uranium-234	1.7 E+1	NE	NE	pCi
Thorium-230	2.6 E+2	NE	NE	pCi
Radium-226 + 5 dtrs	1.9 E+1	NE	NE	pCi
Lead-210 + 2 dtrs	7.2 E+1	NE	NE	pCi
ACTINIUM SERIES				
Uranium-235 + 1 dtr	8.6 E-1	NE	NE	pCi
THORIUM SERIES				
Thorium-232 + 10 dtrs	2.4 E+1	NE	NE	pCi

a "NE" No exposure anticipated because the exposure pathway is not complete.

Table A.3-11 Calculated Intakes for Future Landfill Grounds Keeper Scenario - Area 1

Constituent	Exposure Route: Soil Ingestion	Exposure Route: Inhalation	Exposure Route: Dermal Absorption	Units
Uranium Series				
Uranium-238 + 2 dtrs	2.3 E+2	1.2 E+0	NE[a]	pCi
Uranium-234	2.4 E+2	1.3 E+0	NE	pCi
Thorium-230	1.6 E+4	8.4 E+1	NE	pCi
Radium-226 + 8 dtrs	6.4 E+3	3.3 E+1 [b]	NE	pCi
Actinium Series				
Uranium-235 + 1 dtr	1.2 E+1	6.2 E-2	NE	pCi
Protactinium-231+ 8 dtrs	7.2 E+2	3.8 E+0	NE	pCi
Thorium Series				
Thorium-232 + 10 dtrs	5.1 E+1	2.7 E-1	NE	pCi
Inorganic Chemicals				
Arsenic				
(Carcinogenic)	1.4 E-7	7.3 E-10	2.9 E-9	mg/kg-d
(Noncarcinogenic)	1.6 E-6	NS [c]	3.3 E-8	mg/kg-d
Organic Chemicals				
Aroclor-1254				
(Carcinogenic)	7.5 E-10	3.9 E-12	2.9 E-11	mg/kg-d
(Noncarcinogenic)	8.0 E-9	NS	3.1 E-10	mg/kg-d

[a] "NE" indicates that the exposure route is not applicable.

[b] Inhalation value is for particulates only. Radon intake is 1.3 E+3 pCi.

[c] "NS" indicates that intake calculation is not applicable because no toxicity value is available to quantify risk/hazard index.

Table A.3-12 Calculated Intakes for Future Landfill Grounds Keeper Scenario - Area 2

Constituent	Exposure Route: Soil Ingestion	Exposure Route: Inhalation	Exposure Route: Dermal Absorption	Units
Uranium Series				
Uranium-238 + 2 dtrs	1.7 E+2	8.6 E-1	NE[a]	pCi
Uranium-234	3.1 E+2	1.6 E+0	NE	pCi
Thorium-230	1.8 E+4	9.2 E+1	NE	pCi
Radium-226 + 8 dtrs	7.6 E+3	4.0 E+1 [b]	NE	pCi
Actinium Series				
Uranium-235 + 1 dtr	1.2 E+1	6.2 E-2	NE	pCi
Protactinium-231+ 8 dtrs	1.1 E+3	5.8 E+0	NE	pCi
Thorium Series				
Thorium-232 + 10 dtrs	7.2 E+1	3.8 E-1	NE	pCi
Inorganic Chemicals				
Arsenic				
(Carcinogenic)	1.6 E-8	8.3 E-11	3.3 E-10	mg/kg-d
(Noncarcinogenic)	1.8 E-7	NS [c]	3.7 E-9	mg/kg-d
Lead				
(Carcinogenic)	NS	NS	NS	mg/kg-d
(Noncarcinogenic)	NS	NS	NS	mg/kg-d
Uranium				
(Carcinogenic)	NS	NS	NS	mg/kg-d
(Noncarcinogenic)	2.9 E-6	NS	NS	mg/kg-d
Organic Chemicals				
Aroclor-1254				
(Carcinogenic)	1.1 E-9	3.9 E-12	4.3 E-11	mg/kg-d
(Noncarcinogenic)	1.2 E-8	NS	4.5 E-10	mg/kg-d

[a] "NE" indicates that the exposure route is not applicable.

[b] Inhalation value is for particulates only. Radon intake is 4.6 E+3 pCi.

[c] "NS" indicates that intake calculation is not applicable because no toxicity value is available to quantify risk/hazard index.

Table A.3-13 Calculated Intakes for Future Adjacent Building User Scenario – Area 1

Constituent	Exposure Route: Soil Ingestion	Exposure Route: Inhalation	Exposure Route: Dermal Absorption	Units
Uranium Series				
Uranium-238 + 2 dtrs	NE[a]	NE	NE	pCi
Uranium-234	NE	NE	NE	pCi
Thorium-230	NE	NE	NE	pCi
Radium-226 + 8 dtrs	NE	NE	NE	pCi
Actinium Series				
Uranium-235 + 1 dtr	NE	NE	NE	pCi
Protactinium-231+ 8 dtrs	NE	NE	NE	pCi
Thorium Series				
Thorium-232 + 10 dtrs	NE	NE	NE	pCi
Inorganic Chemicals				
Arsenic				
(Carcinogenic)	NE	NE	NE	mg/kg-d
(Noncarcinogenic)	NE	NE, NS [b]	NE	mg/kg-d
Organic Chemicals				
Aroclor-1254				
(Carcinogenic)	NE	NE	NE	mg/kg-d
(Noncarcinogenic)	NE	NE, NS	NE	mg/kg-d

[a] "NE" indicates that the exposure route is not applicable.

[b] "NS" indicates that intake calculation is not applicable because no toxicity value is available to quantify risk/hazard index.

Table A.3-14 Calculated Intakes for Future Adjacent Building User Scenario – Area 2

Constituent	Exposure Route: Soil Ingestion	Exposure Route: Inhalation	Exposure Route: Dermal Absorption	Units
Uranium Series				
Uranium-238 + 2 dtrs	NE[a]	NE	NE	pCi
Uranium-234	NE	NE	NE	pCi
Thorium-230	NE	NE	NE	pCi
Radium-226 + 8 dtrs	NE	NE	NE	pCi
Actinium Series				
Uranium-235 + 1 dtr	NE	NE	NE	pCi
Protactinium-231+ 8 dtrs	NE	NE	NE	pCi
Thorium Series				
Thorium-232 + 10 dtrs	NE	NE	NE	pCi
Inorganic Chemicals				
Arsenic				
(Carcinogenic)	NE	NE	NE	mg/kg-d
(Noncarcinogenic)	NE	NS[b]	NE	mg/kg-d
Lead				
(Carcinogenic)	NE, NS	NE, NS	NE, NS	mg/kg-d
(Noncarcinogenic)	NE, NS	NE, NS	NE, NS	mg/kg-d
Uranium				
(Carcinogenic)	NE, NS	NE, NS	NE, NS	mg/kg-d
(Noncarcinogenic)	NE	NE, NS	NE, NS	mg/kg-d
Organic Chemicals				
Aroclor-1254				
(Carcinogenic)	NE	NE	NE	mg/kg-d
(Noncarcinogenic)	NE	NE, NS	NE	mg/kg-d

[a] "NE" indicates that the exposure route is not applicable.

[b] "NS" indicates that intake calculation is not applicable because no toxicity value is available to quantify risk/hazard index.

Table A.3-15 Calculated Intakes for Future Storage Yard Worker Scenario – Area 1

Constituent	Exposure Route: Soil Ingestion	Exposure Route: Inhalation	Exposure Route: Dermal Absorption	Units
Uranium Series				
Uranium-238 + 2 dtrs	NE[a]	NE	NE	pCi
Uranium-234	NE	NE	NE	pCi
Thorium-230	NE	NE	NE	pCi
Radium-226 + 8 dtrs	NE	NE	NE	pCi
Actinium Series				
Uranium-235 + 1 dtr	NE	NE	NE	pCi
Protactinium-231+ 8 dtrs	NE	NE	NE	pCi
Thorium Series				
Thorium-232 + 10 dtrs	NE	NE	NE	pCi
Inorganic Chemicals				
Arsenic				
(Carcinogenic)	NE	NE	NE	mg/kg-d
(Noncarcinogenic)	NE	NE, NS [b]	NE	mg/kg-d
Organic Chemicals				
Aroclor-1254				
(Carcinogenic)	NE	NE	NE	mg/kg-d
(Noncarcinogenic)	NE	NE, NS	NE	mg/kg-d

[a] "NE" indicates that the exposure route is not applicable.

[b] "NS" indicates that intake calculation is not applicable because no toxicity value is available to quantify risk/hazard index.

Table A.3-16 Calculated Intakes for Future Storage Yard Worker Scenario – Area 2

Constituent	Exposure Route: Soil Ingestion	Exposure Route: Inhalation	Exposure Route: Dermal Absorption	Units
Uranium Series				
Uranium-238 + 2 dtrs	NE[a]	NE	NE	pCi
Uranium-234	NE	NE	NE	pCi
Thorium-230	NE	NE	NE	pCi
Radium-226 + 8 dtrs	NE	NE	NE	pCi
Actinium Series				
Uranium-235 + 1 dtr	NE	NE	NE	pCi
Protactinium-231+ 8 dtrs	NE	NE	NE	pCi
Thorium Series				
Thorium-232 + 10 dtrs	NE	NE	NE	pCi
Inorganic Chemicals				
Arsenic				
(Carcinogenic)	NE	NE	NE	mg/kg-d
(Noncarcinogenic)	NE	NE, NS [b]	NE	mg/kg-d
Lead				
(Carcinogenic)	NE, NS	NE, NS	NE, NS	mg/kg-d
(Noncarcinogenic)	NE, NS	NE, NS	NE, NS	mg/kg-d
Uranium				
(Carcinogenic)	NE, NS	NE, NS	NE, NS	mg/kg-d
(Noncarcinogenic)	NE	NE, NS	NE, NS	mg/kg-d
Organic Chemicals				
Aroclor-1254				
(Carcinogenic)	NE	NE	NE	mg/kg-d
(Noncarcinogenic)	NE	NE, NS	NE	mg/kg-d

[a] "NE" indicates that the exposure route is not applicable.

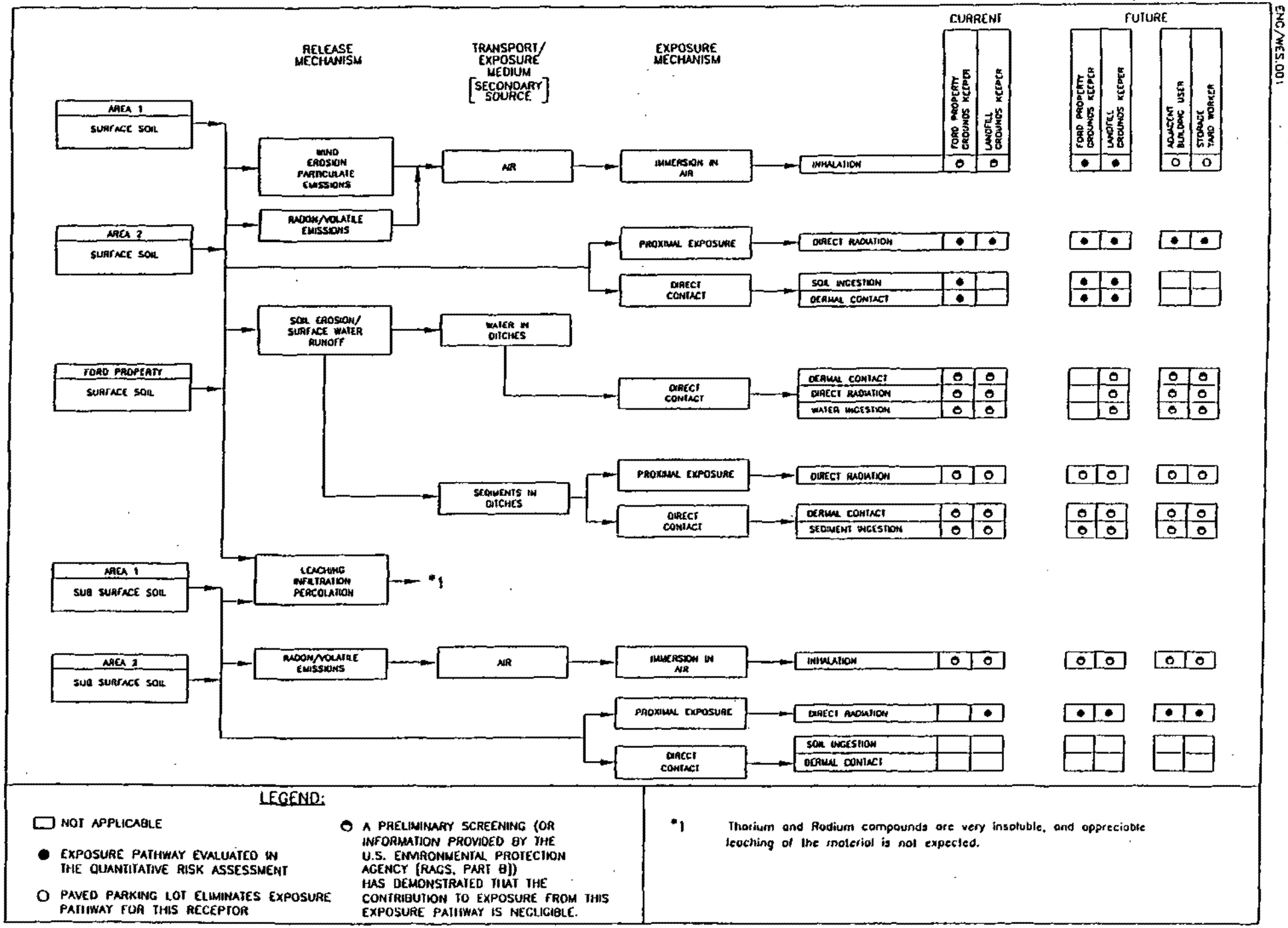
[b] "NS" indicates that intake calculation is not applicable because no toxicity value is available to quantify risk/hazard index.

Table A.3-17 Calculated Intakes for Future Ford Property Grounds Keeper Scenario

Constituent	Exposure Route: Soil Ingestion	Exposure Route: Inhalation	Exposure Route: Dermal Absorption	Units
Uranium Series				
Uranium-238 + 2 dtrs	1.7 E+1	2.2 E-2	NE[a]	pCi
Uranium-234	1.7 E+1	2.2 E-2	NE	pCi
Thorium-230	2.6 E+2	3.4 E-1	NE	pCi
Radium-226 + 8 dtrs	1.0 E+2	1.3 E-1 [b]	NE	pCi
Actinium Series				
Uranium-235 + 1 dtr	8.6 E-1	1.1 E-3	NE	pCi
Thorium Series				
Thorium-232 + 10 dtrs	2.4 E+1	3.1 E-2	NE	pCi

[a] "NE" indicates that the exposure route is not applicable.

[b] Inhalation value is for particulates only. Radon intake is 1.8 E+1 pCi.



LEGEND:

- ☐ NOT APPLICABLE
- ● EXPOSURE PATHWAY EVALUATED IN THE QUANTITATIVE RISK ASSESSMENT
- ○ PAVED PARKING LOT ELIMINATES EXPOSURE PATHWAY FOR THIS RECEPTOR
- ◔ A PRELIMINARY SCREENING (OR INFORMATION PROVIDED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY [RAGS, PART B]) HAS DEMONSTRATED THAT THE CONTRIBUTION TO EXPOSURE FROM THIS EXPOSURE PATHWAY IS NEGLIGIBLE.

*1 Thorium and Radium compounds are very insoluble, and appreciable leaching of the material is not expected.

FIGURE A.3-1: Conceptual Model

A.4.0 TOXICITY ASSESSMENT

This section presents a brief discussion of the carcinogenic and systemic effects of the chemicals, and related toxicological information, selected as COPCs in Section A.2.0. Section A.4.1 presents the methodologies, assumptions, and sources of information used to perform the toxicity assessment. Toxicological profiles are included in Section A.4.3.

A.4.1 TOXICITY INFORMATION FOR CHEMICALS OF POTENTIAL CONCERN

Certain radioactive and non-radioactive chemicals identified in Operable Unit 1 environmental media are known or potential carcinogens in humans. In evaluating the toxicity of chemicals, the EPA methodology assumes that any dose of a carcinogen may result in cancer induction. This "nonthreshold" hypothesis assumes there is essentially no level of exposure that does not pose some level of carcinogenic risk.

As pointed out by EPA (1989a), certain fundamental differences exist between radionuclides and non-radioactive chemicals that somewhat simplify the toxicity assessment for radionuclides. Because of these differences, the carcinogenic effects of radiation and non-radioactive chemicals are presented separately.

A.4.1.1 Radiocarcinogens

Some elements have isotopes consisting of unstable atoms (i.e., they undergo spontaneous transformation into different kinds of elements). These isotopes are said to be radioactive, and the transformation process is known as radioactive decay. Radioactive decay is usually accompanied by the emission of charged particles and/or gamma rays. These emissions are called radiation and consist of three types: alpha, beta, and gamma.

Alpha and beta radiation consist of charged particles capable of ionizing matter. These radiations generally have limited ability to penetrate deeply into materials and can be shielded by skin, air, and clothing. Alpha particles are composed of two protons and two neutrons. Because of their large mass and charge, alpha particles expend their large energies in short distances and may cause damage to living cells depending on the proximity of the cell to the radioactive material emitting the alpha particle. Beta particles are electrons ejected at high speeds from the nucleus of an unstable (radioactive) nucleus. Beta particles are lighter than alpha particles and deposit less energy per volume of tissue than alpha particles. They tend to penetrate farther into matter than

alpha particles. Beta particles of sufficient energy may penetrate up to a few millimeters into exposed skin.

In most cases, the emission of an alpha or beta particle from an atom is followed by the release of gamma radiation. Depending on their energies, these radiations may have considerably more penetration power than either alpha or beta radiation and are thus more difficult to shield. Gamma radiation is energy emitted as photons from the nucleus of a radioactive atom. Gamma radiation penetrates the skin and, with ample energy, can pass through the entire body.

Radiation exposures can be separated into external and internal exposures. External exposure occurs when the radiation source is outside the body. Because alpha and beta radiation generally have a low penetrating power, skin and air become effective radiation shields in most cases. Therefore, external exposure to gamma radiation is the primary external exposure concern at naturally-occurring environmental levels. Internal exposure occurs after radionuclides enter the body via inhalation or ingestion. For internal exposures, radionuclides that emit alpha and beta particles become more important because their energy is directly absorbed by living cells.

Radioactive contamination within Operable Unit 1 is characterized as low-level ionizing radiation. The principal adverse biological effect associated with exposure to ionizing radiation from radioactive substances in the environment is cell alteration resulting in carcinogenicity (EPA 1989a). Carcinogenicity is the ability to produce cancer. The carcinogenicity of a radionuclide depends on several factors including:

- Type of radiation emitted by the radionuclide,
- Energy of the radiation emitted,
- Radiological half-life of the radionuclide,
- Retention and concentration characteristics of the radionuclide in the human body, and
- Radioactive characteristics of decay products (daughter radionuclides).

EPA considers all radionuclides to be Class A carcinogens. Carcinogenicity is believed to be the limiting deleterious effect at the levels of radiation dose encountered within Operable Unit 1 and has been used as the sole basis for assessing the radiation-related human health risks from above-background concentrations of radionuclides (EPA 1989a). The EPA factors used in this report are based solely on carcinogenic effects.

Two additional adverse biological effects associated with ionizing radiation are mutagenicity and teratogenicity.

Mutagenesis is radiation damage of reproductive cells. Genetic mutations in reproductive cells may lead to fetal defects if the damage is expressed via reproduction. The frequency of radiation-induced genetic impairment is believed to be relatively small in humans in comparison with the magnitude of detriment associated with spontaneous genetic diseases. Indeed, to date, radiation-induced genetic effects have never been shown to occur in humans.

Teratogenesis is radiation damage to the embryo, as a consequence of *in utero* exposures, and increases the incidence of congenital malformations as a result of permanent structural or functional deviations. The malformations produced in the embryo depend on which cells, tissues, or organs in the fetus are most actively differentiating at the time of exposure.

All three types of ionizing radiation (alpha, beta, and gamma) are assumed to have the ability to produce carcinogenesis, mutagenesis, and teratogenesis. Carcinogenesis is of greatest concern for this report.

The relationship between radiation dose and health effects is relatively well characterized for high doses (i.e., acute whole-body doses >10 rad). Lower doses may constitute a health risk, but a direct cause-and-effect relationship is difficult to establish because many different processes can produce a particular effect in a specific individual. For low doses, health effects are presumed to occur but can only be estimated statistically. Therefore, the risk of cancer incidence from exposure to low levels of ionizing radiation must be extrapolated from incidence data at higher doses. A linear, no-threshold relationship between radiation dose and risk of cancer incidence is assumed.

Under CERCLA methodology, the EPA bases risk over a lifetime on an assumed unit intake of, or external exposure to, a radionuclide. The annual radiation dose equivalent from the radionuclide to each organ in each year of life is calculated. The average excess number of all types of radiation-induced fatal cancers that occur in a year is then estimated for the corresponding dose equivalents received during that year and relevant preceding years. The excess number of radiation-induced fatal cancers is derived from epidemiological data, extrapolation from high radiation doses to low doses, and hypothetical models for projecting risk through a lifetime. The relationship between cancer incidence and exposure to radioactive

materials is quantified by using mathematical extrapolation models, which estimate the largest possible linear slope (within the 95 percent confidence limit) at low extrapolated doses consistent with the data. This relationship is referred to as the slope factor (SF). Because EPA is concerned with assessing cancer incidence, each radionuclide slope factor has been calculated by dividing the excess fatal cancer risk for that radionuclide by the mortality-to-incidence risk ratio (EPA 1989a) for the types of cancer induced by that radionuclide. This radionuclide-specific carcinogenic slope factor, which is analogous to the slope factors developed for chemical carcinogens, is characterized as the "maximum likelihood estimate of the age-averaged lifetime total excess cancer risk per unit intake or exposure" (EPA 1989a). That is, the true risk to humans, although not identifiable, is not likely to exceed this upperbound estimate; it may, in fact, be lower.

The EPA Office of Emergency and Remedial Response has calculated carcinogenic slope factors for radionuclides of potential concern at Superfund sites. These values are listed in EPA's Health Effects Assessment Summary Tables (HEAST, Table 4A) (EPA 1997c) and are presented as the risk of cancer incidence per unit intake of a radionuclide contaminant (in units of pCi^{-1}) for inhalation and ingestion exposure routes. For external exposure from radionuclides in soil, the slope factor is expressed in units of g/pCi-y. The radionuclide slope factors used in this assessment are presented in Table A.4-1.

A.4.1.2 Chemical Carcinogens

The toxicity information considered in the assessment of potential carcinogenic risks associated with exposure to chemicals includes (1) a weight-of-evidence classification and (2) a slope factor. The weight-of-evidence classification qualitatively describes the likelihood that a chemical is a human carcinogen and is based on an evaluation of the available data from human and animal studies. A chemical may be placed in one of three groups in EPA's classification system to indicate its potential for carcinogenic effects: Group A, a human carcinogen; Group B1 or B2, a probable human carcinogen; and Group C, a possible human carcinogen. Chemicals that cannot be classified as human carcinogens because of a lack of data are placed in Group D, and those for which there is no evidence of carcinogenicity in humans are placed in Group E.

The cancer slope factor is the toxicity value used to quantitatively express the carcinogenic hazard of cancer-causing constituents. It is defined as the upper-bound estimate of the probability of cancer incidence per unit dose averaged over a lifetime. Slope factors are derived from studies of carcinogenicity in humans and/or laboratory animals and are typically calculated for compounds in Groups A, B1, and B2. Slope factors are specific to a chemical and route of

exposure and expressed in units of $(mg/kg\text{-}day)^{-1}$ for both oral and inhalation routes. The induction of cancer by dermal absorption is evaluated using oral slope factors. Inhalation cancer toxicity values are usually expressed as inhalation unit risks in units of reciprocal $\mu g/m^3$, i.e., $(1/\mu g/m^3)$. Because cancer risk characterization requires an estimate of reciprocal dose in units of 1/mg/kg-day, the inhalation unit risk must be converted to the mathematical equivalent of an inhalation cancer slope factor, or risk per unit dose (mg/kg-day). This is done by assuming humans weigh 70 kg and inhale 20 m^3 of air/day, i.e., the inhalation unit risk $(1/\mu g/m^3)$ divided by 20 m^3/day, multiplied by 70 kg and multiplied by 1000 $\mu g/mg$ yields the mathematical equivalent of an inhalation slope factor (1/mg/kg-day). Slope factors for chemical constituents are presented in Table A.4-2. The primary sources of these toxicity values are EPA's Integrated Risk Information System (IRIS) (EPA 2000) and the quarterly updated HEAST (EPA 1997c). Other EPA sources of cancer slope factors (e.g., the U.S. EPA, Office of Research and Development, Environmental Criteria and Assessment Office) were also consulted.

A.4.1.3 Noncarcinogenic Chemicals

For noncarcinogens, it is assumed that a dose exists below which no adverse health effects will be seen. Below this "threshold" dose, exposure to a chemical can be tolerated without adverse effects. For noncarcinogens, a range of exposure exists that can be tolerated without adverse effects. Toxic effects are manifested only when physiologic protective mechanisms are overcome by exposures to a constituent above its threshold level. Maternal and developmental endpoints are considered systemic toxicity.

Many chemicals, whether or not associated with carcinogenicity, are associated with non-carcinogenic effects. The evaluation of noncarcinogenic effects (EPA 1989a) involves:

- Qualitative identification of the adverse effect(s) associated with the chemical; these may differ depending on the duration or exposure (acute, subchronic, chronic)
- Identification of the critical effect (or threshold effect) for each duration of exposure, i.e., the adverse effect that occurs at the lowest dose (e.g., if liver damage occurs at 20 mg/kg-day, and mortality occurs at 100 mg/kg-day, liver damage is the critical effect)
- Quantification of the threshold dose for the critical effect for each duration of exposure (i.e., the dose at or above which the effect occurs, and below which the effect dose not occur
- Development of an uncertainty factor, i.e., quantification of the uncertainty associated with interspecies extrapolation, intraspecies variation in sensitivity, severity of the critical effect and slope of the dose-response curve, and deficiencies in the database, in regard to developing a reference dose (RfD) for human exposure; and
- Identification of the target organ(s) for the critical effect for each route of exposure.

The potential for noncarcinogenic health effects resulting from exposure to chemical contaminants is assessed by comparing an exposure estimate (intake) to a reference dose (RfD). The RfD is expressed in units of milligrams per kilogram per day (mg/kg/day) and represents a daily intake of contaminant per kilogram of body weight that is not sufficient to cause the threshold effect of concern for the contaminant. An RfD is specific to the chemical, the route of exposure, and the duration over which the exposure occurs. Separate RfDs are presented for ingestion and inhalation pathways. The quarterly updated HEAST presents reference concentrations (RfCs) for the inhalation route (EPA 1997c). Inhalation noncancer toxicity values are usually expressed as inhalation reference concentrations (RfCs) in units of milligrams per cubic meter (mg/m^3). Because noncancer risk characterization requires an estimate of dose in units of mg/kg/day, the inhalation RfC must be converted to an inhalation RfD using the inhalation rate. This is done by assuming humans weigh 70 kg and inhale 20 m^3 of air per day [i.e., the inhalation RfC (mg/m^3) multiplied by 20 m^3/day and divided by 70 kg yields an inhalation RfD (mg/kg/day)]. To derive an RfD, the EPA reviews all relevant human and animal studies for each compound and selects the study (studies) pertinent to the derivation of the specific RfD. Each study is evaluated to determine the no-observed-adverse-effect level (NOAEL) or, if data are inadequate for such a determination, the lowest-observed-adverse-effect level (LOAEL). The NOAEL corresponds to the dose, in mg/kg/day, that can be administered over a lifetime without inducing observable adverse effects. The LOAEL corresponds to the lowest daily dose, in mg/kg/d, that can be administered over a lifetime that induces an observable adverse effect. The toxic effect characterized by the LOAEL is referred to as the "critical effect." To derive an RfD, the NOAEL (or LOAEL) is divided by uncertainty factors to ensure that the RfD will be protective of human health. Uncertainty factors are applied to account for: 1) extrapolation of data from laboratory animals to humans (interspecies extrapolation), 2) variation in human sensitivity to the toxic effects of a compound (intraspecies differences), 3) derivation of a chronic RfD based on a subchronic rather than a chronic study, and/or 4) derivation of an RfD from the LOAEL rather than the NOAEL. In addition to these uncertainty factors, modifying factors between 0 and 10 may be applied to reflect additional qualitative considerations in evaluating the data. For most compounds, the modifying factor is 1.

Reference doses for noncarcinogenic COPCs are presented in Table A.4-3. The primary source of values for reference doses is IRIS, an EPA on-line database that contains current health risk and regulatory information for many chemicals (EPA 2000). The RfDs and RfCs are also

tabulated in HEAST (EPA 1997c). Other EPA sources of provisional RfD values were also consulted when available.

A.4.2 DERMAL EVALUATION OF CHEMICALS

Dermal RfD and slope factor values were derived from the corresponding oral values. In the derivation of a dermal RfD, the oral RfD was multiplied by the gastrointestinal absorption factor (GAF), expressed as a unitless fraction. The resulting dermal RfD is an RfD based on absorbed dose, which is the appropriate value with which to compare a dermal doses because dermal doses are expressed as absorbed rather than exposure doses. In a similar manner, and for the same reasons, a dermal SF is derived by dividing the oral cancer slope factor by the GAF.

Not all COPCs have specific GAF values. When quantitative data are insufficient, a default GAF is used. EPA (1995) recommends a GAF of 0.2 for the inorganic chemicals evaluated in this study.

A.4.3 TOXICITY PROFILES

This section provides detailed evaluations for those chemicals that are most prevalent in environmental media associated with Operable Unit 1. Chemicals for which there is an issue requiring explanation (e.g., use of a biokinetic model rather than an oral or inhalation RfD) are also included. Data evaluated for each contaminant include noncancer toxicity, and carcinogenicity. The chemicals are profiled in alphabetical order.

A.4.3.1 Actinium

Actinium occurs naturally as a radioactive decay product in the thorium-232 and uranium-235 decay series and has no stable (i.e., nonradioactive) forms. Because of the much shorter half-lives of the actinium radionuclides compared to the thorium-232 and uranium-235, the relative abundance of actinium (by mass) in nature is much lower than that of thorium and uranium. The decay of radioactive radium-228 in the thorium-232 decay series results in the production of actinium-228. Because of its short half-life (6.1 hours), the radiation dose from this radionuclide is included in that reported for the thorium-232 decay series in this assessment. Actinium-227 is primarily a beta emitter, and it poses an internal health hazard. It is relatively insoluble, so little actinium is absorbed into the blood stream; the small fraction that is absorbed is translocated to the skeleton and liver where it is strongly retained.

A.4.3.2 Aroclor 1254 (Polychlorinated Biphenyls)

The polychlorinated biphenyls (PCBs) are a group of man-made chemicals that contain 209 individual compounds (known as congeners). Seven types of PCB mixtures include 35% of all the different PCBs commercially produced and 98% of PCBs sold in the United States since 1970. Some commercial PCB mixtures are known in the United States by their industrial trade name, Aroclor (e.g., Aroclor 1254, Aroclor 1260). The name Aroclor 1254 signifies that the molecule contains 12 carbon atoms (the first two digits) and about 54% chlorine by weight (the second two digits)(ATSDR 1993).

PCBs can be ingested or inhaled and can cause skin and nose irritations. Health effects from exposure to PCBs observed in rats include (1) liver damage and sometimes death after ingestion of large amounts of PCBs for a short period and (2) liver, stomach, and thyroid gland injuries, anemia, acne, and damaged reproduction organs after ingestion of smaller amounts of PCBs for a long period. However, little conclusive evidence of the effects of PCBs on humans is available. Although rats that ate certain PCB mixtures throughout their lives developed liver cancers, whether the same effects would occur in people is unknown. After inhalation exposure, workers have exhibited respiratory tract and eye irritation, coughs, and tightness of the chest, as well as gastrointestinal symptoms (ATSDR 1993).

Studies of PCB-exposed workers provide inconclusive evidence for exposure-related cancer; however, an excess risk of cancer of the liver, biliary tract, and gall bladder has been reported in workers in two capacitor plants where PCB mixtures are commonly used (ATSDR 1993). EPA has classified Aroclor 1254 in a weight-of-evidence carcinogenicity group. However, PCBs have been classified in Group B2, probable human carcinogens (EPA 2000).

A.4.3.3 Arsenic

The only noncancer effects in humans clearly attributable to chronic oral exposure to arsenic are dermal hyperpigmentation and keratosis, as revealed by studies of several hundred Chinese exposed to naturally occurring arsenic in well water (Tseng 1977; Tseng et al. 1968; EPA 2000). Similar effects were observed in persons exposed to high levels of arsenic in water in Utah and the northern part of Mexico (Cebrian et al. 1983; Southwick et al. 1983). Occupational exposure (predominantly inhalation) is also associated with neurological deficits, anemia, and cardiovascular effects (Ishinishi et al. 1986), but concomitant exposure to other chemicals cannot be ruled out. The principal target organ for arsenic appears to be the skin. The nervous system and cardiovascular systems appear to be less significant target organs. Inorganic arsenic may be

an essential nutrient, exerting beneficial effects on growth, health, and feed conversion efficiency (Underwood 1977).

EPA classifies arsenic as a Group A (human carcinogen). Inhalation exposure is associated with increased risk of lung cancer in persons employed as smelter workers, in arsenical pesticide applicators, and in a population residing near a pesticide manufacturing plant (EPA 2000). Oral exposure to high levels in well water is associated with increased risk of skin cancer (Tseng 1977; EPA 2000). Extensive animal testing with various forms of arsenic given by many routes of exposure to several species, however, has not demonstrated the carcinogenicity of arsenic (International Agency for Research on Cancer [IARC] 1980).

A.4.3.4 Lead

Studies in humans indicate that an average of 10 percent of ingested lead is absorbed, but estimates as high as 40 percent were obtained in some individuals (Tsuchiya 1986). Nutritional factors have a profound effect on GI absorption efficiency. Children absorb ingested lead more efficiently than adults do; absorption efficiencies up to 53 percent were recorded for children three months to eight years of age. Similar results were obtained for laboratory animals; absorption efficiencies of 5 to 10 percent were obtained for adults and 50 percent were obtained for young animals. The deposition rate of inhaled lead averages approximately 30 to 50 percent, depending on particle size, with as much as 60 percent deposition of very small particles (0.03 μm) near highways. All lead deposited in the lungs is eventually absorbed.

The noncancer toxicity of lead to humans has been well characterized through decades of medical observation and scientific research (EPA 1994b). The primary effects of long-term exposure are neurological and hematological. Limited occupational data indicate that long-term exposure to lead may induce kidney damage. The principal target organs of lead toxicity are the erythrocyte and the nervous system. Some of the effects on the blood, particularly changes in levels of certain blood enzymes, and subtle neurobehavioral changes in children, appear to occur at levels so low as to be considered nonthreshold effects.

The EPA (2000) determined that it is inappropriate to derive an RfD for oral exposure to lead for several reasons. First, the use of an RfD assumes that a threshold for toxicity exists, below which adverse effects are not expected to occur; however, the most sensitive effects of lead exposure, impaired neurobehavioral development in children and altered blood enzyme levels associated with anemia, may occur at blood lead concentrations so low as to be considered practically nonthreshold in nature. Second, RfD values are specific for the route of exposure for

which they are derived. Lead, however, is ubiquitous, so that exposure occurs from virtually all media and by all pathways simultaneously, making it practically impossible to quantify the contribution to blood lead from any one route of exposure. Finally, the dose-response relationships common to many toxicants, and upon which derivation of an RfD is based, do not hold true for lead. This is because the fate of lead within the body depends, in part, on the amount and rate of previous exposures, the age of the recipient, and the rate of exposure. There is, however, a reasonably good correlation between blood lead concentration and effect. Therefore, blood lead concentration is the appropriate parameter on which to base the regulation of lead.

EPA (2000) classifies lead in cancer weight-of-evidence Group B2 (probable human carcinogen), based on inadequate evidence of cancer in humans and sufficient animal evidence. The human data consist of several epidemiologic occupational studies that yielded confusing results. All of the studies lacked quantitative exposure data and failed to control for smoking and concomitant exposure to other possibly carcinogenic metals. Rat and mouse bioassays showed statistically significant increases in renal tumors following dietary and subcutaneous exposure to several soluble lead salts. Various lead compounds were observed to induce chromosomal alterations in vivo and in vitro, sister chromatid exchange in exposed workers, and cell transformation in Syrian hamster embryo cells; to enhance simian adenovirus induction; and to alter molecular processes that regulate gene expression. EPA (2000) declined to estimate risk for oral exposure to lead because many factors (e.g., age, general health, nutritional status, existing body burden and duration of exposure) influence the bioavailability of ingested lead, introducing a great deal of uncertainty into any estimate of risk.

Four isotopes of lead exist in the uranium-238, thorium-232 and uranium-235 decay series. Lead-214 (half-life of 27 minutes) and lead-210 (half-life of 22 years) are members of the uranium-238 decay series. Lead-212 (half-life of 11 hours) is a member of the thorium-232 decay series, and lead-211 (half-life of 36 minutes) is a member of the uranium-235 decay series. Of these four radionuclides, only lead-210 has a long enough half-life to warrant its consideration as a separate COPC. The health risks associated with the other three lead isotopes are accounted for in the slope factors of other long-lived parent radionuclides. Lead-210 is a beta emitter, and thus poses an internal exposure hazard. Lead has a relatively high absorption rate from the gastrointestinal tract; after absorption, it is deposited in the skeleton, liver, and kidney but is strongly retained only by mineral bone.

A.4.3.5 Protactinium

Protactinium occurs naturally as a radioactive decay product in the uranium-235 and uranium-238 decay series and has no stable (i.e., nonradioactive) forms. Because of the much shorter half-lives of protactinium radionuclides compared with their uranium parents, the relative abundance of protactinium (by mass) in nature is much lower than that for uranium. Protactinium-234m (metastable), a decay product of uranium-238, is a beta emitter; because of its short half-life (1.2 minutes), it is not considered separately from uranium-238. Protactinium-231 is a long-lived decay product in the uranium-235 decay series (half-life of 33,000 years). It is primarily an alpha emitter; however, a wide range of gamma rays is also emitted as this radionuclide decays. Hence, protactinium poses an internal as well as an external health hazard.

The solubility of protactinium in the bloodstream is relatively low. Rat studies have shown that protactinium entering the bloodstream is deposited primarily in the skeleton, whereas the liver and kidney are secondary sites of deposition. Protactinium deposited in the skeleton is retained there with a biological half-life of more that 100 days; protactinium deposited in the liver or kidneys exhibits a biphasic retention, the two compartments having biological half-lives of about 10 and 60 days, respectively. Data from studies of a man accidentally contaminated with protactinium-231 through a puncture wound in his hand indicate that, after an early phase of excretion, the remaining fraction of protactinium is retained in the body almost indefinitely, probably mainly on the skeleton (ICRP 1981a).

A.4.3.6 Radium

No toxic effects of exposure to radium are documented and EPA has not developed an RfD for radium; therefore, the health hazard for radium is associated with potential radiocarcinogenic effects from its constituent isotopes.

Radium is a widespread, naturally-occurring alkaline earth metal. Radium-226 is a member of the uranium-238 decay series, radium-228 and radium-224 are members of the thorium-232 decay series, and radium-223 is a member of the uranium-235 decay series. Radium-226 in an alpha-gamma emitter with a half-life of 1600 years; radium-228 is a beta-gamma emitter with a half-life of 5.8 years. Because of the short half-life of radium-224 (half-life of 3.6 days) and radium-223 (half-life of 11 days), the health risks associated with these two radium isotopes are included with the slope factors for thorium-228 and actinium-227, respectively. The metabolic behavior of radium in the body is similar to that of calcium. Thus, an appreciable fraction of ingested radium is deposited nonuniformly in the bone. The release of radium from the bone is slow, so chronic intake can result in very high concentrations in bone.

The majority of epidemiological data on the health effects of radium-226 and radium-228 in humans comes from studies of radium dial painters, radium chemists, and technicians exposed through medical procedures in the early 1900's (NRC 1988). These studies, as well as studies on experimental animals, indicate that chronic exposure to radium can induce bone sarcomas. The minimum latency period is seven years after the first exposure, but tumors can continue to appear throughout a lifetime. Carcinomas in the paranasal sinuses and mastoid air cells have been shown to be associated with radium-226; causation in this case is attributed to generation of radon-222 by radium-226 decay and subsequent irradiation of the sinuses and mastoid epithelial tissues by radon-222 and its decay products.

A.4.3.7 Radon And Progeny

Radon is a naturally-occurring radioactive noble gas. Each of the three natural radioactive decay series contains one radon isotope. Radon-222 is the decay product (i.e., daughter) of radium-226 in the uranium-238 decay series, radon-220 is the decay product of radium-224 in the thorium-232 decay series, and radon-219 is the decay product of radium-223 in the uranium-235 decay series. In general, radon-219 poses a much lower risk than the other two radon isotopes because of its very short half-life (4.0 seconds)

Radon-222 is a short-lived alpha emitter (half-life of 3.8 days) that decays into four short-lived radioactive decay products, all of which are heavy metals. Two decay products, polonium-218 and polonium-214, are alpha emitters; two others, lead-214 and bismuth-214, are beta-gamma emitters. Radon-220 is a short-lived alpha emitter (half-life of 55 seconds) that decays to polonium-216, which, in turn, decays by alpha emission to lead-212. Lead-212 is a beta-gamma emitter with a half-life of 11 hours. The lung is the major tissue irradiated by radon-222, radon-220, and their short-lived decay products except for lead-212; lead-212 can be transferred from the lung to other tissues, particularly the blood (red blood cells), kidneys, and bone surfaces (ICRP 1981b).

The primary hazard of radon arises from the inhalation of its short-lived decay products. These metallic decay products, which are charged ions in air, readily attach to dust particles and can be inhaled into the lungs and deposited on the mucous lining of the respiratory tract. Unattached decay products tend to be inhaled deeper into the lungs where the residence time is longer. When alpha emission occurs in the lung, it can damage the cells lining the airways, potentially leading to lung cancer. The association of exposure to radon decay products with human lung cancer has been studied extensively in uranium miners (NRC 1988). These studies have

identified a clear connection between elevated radon exposure and lung cancer incidence. Other health effects observed in uranium miners include emphysema, tuberculosis, renal dysfunction, bronchitis, pneumonia, asthma, and cancers of the skin and stomach. However, miners were exposed to many hazardous substances along with high levels of radon, so it is difficult to determine which effects resulted from exposure to radon alone.

In this assessment, exposure to radon daughters in air is expected to be negligible because the time between generation at the source and inhalation at the exposure point is too small to allow measurable daughter in-growth. To reflect this, the cancer slope factor for radon without its daughters was used in cases when the receptor is breathing outdoor air.

A.4.3.8 Thorium

Thorium is a naturally-occurring radioactive metal. Six isotopes of thorium are present in the three decay series: thorium-234, thorium-232, thorium-231, thorium-230, thorium-228, and thorium-227. Thorium-232 is a primordial element with a very long half-life of 1.4×10^{10} years; thorium-230 is a relatively long-lived alpha emitter with a half-life of 7.7×10^{4} years and is a member of the uranium-238 decay series. Thorium-230, the parent radionuclide of radium-226, is a major contaminant at the West Lake Landfill. Thorium-234, thorium-231,and thorium-227 have short half-lives of 24 days, 26 hours, and 19 days, respectively. The health risks associated with these radionuclides are accounted for in the slope factors of other, longer-lived parent radionuclides. Similarly, the health risk associated with thorium-228 (half-life of 1.9 years) is accounted for in the slope factor for thorium-232.

Most thorium that is inhaled or ingested in food, water, or soil is excreted within a few days, and only a small fraction is absorbed into the bloodstream. Once in the bloodstream, thorium accumulates on bone surfaces where it can persist for several years; therefore, bone cancer is a potential health concern. Studies have shown that, although soluble forms of thorium are absorbed to a greater degree than insoluble forms, no chemical form is absorbed from the gastrointestinal tract in any appreciable amount.

The majority of human data for thorium exposure comes from diagnostic dye studies. Colloidal thorium-232 dioxide (Thorotrast) was injected into patients as a radiographic contrast medium between 1928 and 1955. The epidemiological data from these studies show that the primary health effects of high doses of injected Thorotrast are blood disorders and tumors of the liver (NRC 1988). Risk estimates derived from the Thorotrast studies are appropriate only for Thorotrast injections (e.g., administered doses) because health effects associated with normal

routes of exposure would be very different. However, these studies indicate that thorium could be a human carcinogen.

Few data are available regarding the effects of low exposures to thorium from pathways other than injection, e.g., from inhalation or ingestion. Some evidence was found of increased incidence of lung, pancreatic, and hematopoietic cancers in workers occupationally exposed to thorium via inhalation. However, these workers were also exposed to several other agents that were known to be toxic, so direct causation cannot be inferred (Archer et al. 1973; Polednak et al. 1983; Stehney et al. 1980).

A.4.3.9 Uranium

Uranium is a radioactive heavy metal that occurs ubiquitously in the earth's crust. Natural uranium consists of three isotopes: uranium-238, uranium-235, and uranium-234. These isotopes occur in the relative abundance of 99.27, 0.72, and 0.0055% by weight, respectively. Uranium is an alpha and gamma emitter. Two hazards are associated with uranium compounds: kidney damage caused by the chemical toxicity of soluble uranium compounds and cell damage caused by the ionizing radiation that results from radioactive decay. External exposure is generally not a health concern because uranium emits only a small amount of penetrating gamma radiation.

Gastrointestinal absorption from food or water is the principal source of internally-deposited uranium in the general population. Once ingested, most of the uranium is excreted from the body within a few days. The small fraction absorbed into the bloodstream (less than 1%) is stored uniformly in bone. The major health risk from uranium is associated with its chemical properties, not its radiological properties. Human or animal studies conducted to date have shown little evidence to indicate that adverse health effects result from the radiation exposure associated with natural uranium. Increased incidence of lung cancer has been observed in uranium miners, but this effect is caused by exposure to radon-222, a decay product of uranium (NRC 1988).

Although natural uranium is radioactive, the primary health effect associated with exposure is kidney damage caused by chemical toxicity. No inhalation RfC is available for uranium (EPA 1997c). About 5% of the soluble salts of uranium are absorbed via ingestion. Only a small fraction of inhaled uranium dust penetrates to the alveolar region of the lung, as indicated by low uranium levels in the lungs of workers exposed to uranium dust. Kidney toxicity, which is the main health effect of concern for soluble uranium exposure, may be reversible depending on the level of exposure. A few studies have also reported minor effects on the liver caused by

ingestion and inhalation of uranium compounds. No toxicity information is available from EPA on natural uranium, CASRN 7440-61-1 (IRIS file no. 0259). The chemical toxicity of natural uranium is evaluated quantitatively in the risk assessment using the oral ingestion RfD for soluble uranium salts (IRIS file no. 0421). The RfD for soluble uranium salts is used although soluble forms of uranium are not expected to be found at this site.

Table A.4-1 Radiological Carcinogenic Slope Factors[a]

Constituent	Inhalation Cancer Slope Factor SF_i (pCi^{-1})	Oral Cancer Slope Factor SF_o (pCi^{-1})	External Cancer Slope Factor SF_e (g/pCi-y)
Uranium Series			
Uranium-238 + 2 dtrs	1.24 E-8	6.20 E-11	5.25 E-8
Uranium-234	1.40 E-8	4.44 E-11	2.14 E-11
Thorium-230	1.72 E-8	3.75 E-11	4.40 E-11
Radium-226 + 8 dtrs	6.61 E-9	1.31 E-9	6.74 E-6
Radium-226 + 5 dtrs	2.75 E-9	2.96 E-10	6.74 E-6
Radium-226	2.72 E-9	2.95 E-10	1.31 E-8
Radon-222 + 4 dtrs	7.57 E-12	NA	NA
Radon-222 in Outdoor Air [b]	7.3 E-13	NA	NA
Lead-210 + 2 dtrs	3.86 E-9	1.01 E-9	1.45 E-10
Actinium Series			
Uranium-235 + 1 dtr	1.30 E-8	4.70 E-11	2.65 E-7
Protactinium-231+ 8 dtrs	1.03 E-7	7.75 E-10	6.24 E-7
Thorium Series			
Thorium-232 + 10 dtrs	1.17 E-7	5.11 E-10	4.27 E-6

[a] EPA assumes all radionuclides are Class A carcinogens. Slope factors used are from EPA 1997 "Health Effects Assessment Summary Tables Update," unless noted.

[b] Radon daughters have not had enough time to appear before the released radon-222 reaches the exposure points selected in this risk assessment. To reflect this, the radon-222 slope factor (without daughter contributions) from EPA's March 1994 "Health Effects Assessment Summary Tables Update" was used for outdoor Rn-222 exposures

Table A.4-2 Chemical Carcinogenic Slope Factors [a]

Constituent	Inhalation Cancer Slope Factor SF_i [1/(mg/kg-d)]	Oral Cancer Slope Factor SF_o [1/(mg/kg-d)]	Inhalation Tumor Site	Oral Tumor Site	Cancer Classification	Dermal Cancer Slope Factor SF_d [1/(mg/kg-d)]
Aroclor-1254	2.00 E+0[b]	2.00 E+0[b]	ND[c]	Liver	B2[b]	2.22 E+0
Arsenic	1.54 E+1	1.50 E+0	Respiratory tract	Skin, liver, lung, bladder	A	1.58 E+0
Lead	ND	ND	ND	Kidney	B2	ND
Uranium	ND	ND	ND	ND	ND	ND

[a] References: Integrated Risk Information System (EPA 2000), Health Effects Assessment Summary Tables (EPA 1997c).

[b] Slope Factors for polychlorinated biphenyls are given. Cancer slope factors for Aroclor-1254 are not available.

[c] ND signifies that no data were available.

Table A.4-3 Chemical Reference Doses [a]

Constituent	Inhalation Reference Dose RfD_i (mg/kg-d)	Oral Reference Dose RfD_o (mg/kg-d)	Inhalation Target Organ	Oral Target Organ	Inhalation Uncertainty Factor	Oral Uncertainty Factor	Dermal Reference Dose RfD_d (mg/kg-d)
Aroclor-1254	ND[b]	2.0 E-5	ND	ND	ND	3.0 E+2	1.8 E-5
Arsenic	ND	3.0 E-4	ND	Skin, vascular system	ND	3.0 E+0	2.9 E-4
Lead	ND	ND	CNS[c]	CNS[c]	ND	ND	ND
Uranium [d]	ND	3.0 E-3	ND	Kidney	ND	1.0 E+3	1.9 E-5

[a] References: Integrated Risk Information System (EPA 2000), Health Effects Assessment Summary Tables (EPA 1997c).

[b] ND signifies that no data were available.

[c] CNS signifies Central Nervous System.

[d] Values used are for soluble uranium salts, IRIS file no. 0421. No toxicity information is available from EPA on natural uranium, CASRN 7440-61-1, (IRIS file no. 0259). The RfD for soluble uranium was used, although this form of uranium is not expected to be found at this site.

A.5.0 HEALTH RISK CHARACTERIZATION

This section provides a characterization of the potential human health risks associated with the exposure to COPCs originating in Operable Unit 1. Section A.5.1 introduces the methods used to estimate the type and magnitude of health risks associated with the receptor scenarios selected for quantification in this baseline risk assessment. Section A.5.2 presents the results of the risk assessment calculations for current conditions at Operable Unit 1. Section A.5.3 presents the risk assessment results for assumed future conditions. Section A.5.4 contains a summary of the results.

A.5.1 METHODS USED FOR RISK CHARACTERIZATION

Potential human health effects resulting from exposure to COPCs are estimated using methods established by the EPA. These methods are published in a series of guidance documents including the Risk Assessment Guidance for Superfund, Volume 1, Human Health Evaluation Manual (EPA 1989a). The procedures described by EPA use specific algorithms to calculate human health risks as a function of chemical concentration, human exposure parameters, and toxicity. This approach is designed to be health-protective and is likely to overestimate risks, rather than to underestimate risks.

Under CERCLA, human health effects are divided into two broad categories - carcinogenic risk and toxic effects. A further distinction is made between radiocarcinogenic risks and chemocarcinogenic risks when a mixture of radioactive and nonradioactive chemicals is encountered. The methods used to assess radiological and chemical risks differ slightly to account for potential differences in the cancer induction mechanisms (EPA 1989a). The algorithms to calculate health effects for each of these types of human health effects are presented in the following sections.

A.5.1.1 Carcinogenic Risks

Risks attributed to exposure to chemical carcinogens are estimated as the probability of an individual developing cancer over a lifetime because of exposure to a potential carcinogen. EPA published remedial action objectives in March 8, 1990, for known or suspected carcinogens encountered during the CERCLA process (EPA 1990b):

> "acceptable levels are generally concentration levels that represent an excess upper bound lifetime cancer risk to an individual of between 10^{-4} and 10^{-6}..."
>
> "The 10^{-6} risk level shall be used as the point of departure for determining

remediation goals ...[in] the presence of multiple contaminants at a site or multiple pathways of exposure."

This EPA target range of excess upper bound lifetime cancer risks (10^{-6} to 10^{-4}) and the 10^{-6} "point of departure" are used as reference points during the following discussion of Operable Unit 1 risks.

A.5.1.1.1 Radiocarcinogenic Risks

Procedures for estimating the incremental lifetime cancer risks (ILCRs) resulting from chronic or periodic exposures to a radionuclide are discussed in the following sections. The calculated risk from exposures to radiation includes contributions from both the radionuclide of interest and its appropriate decay products. For example, the ILCR presented in this report for radium-226 currently in the soil is the sum of the risks contributed by the radium-226 and each of its short-lived daughters, such as lead-214 and bismuth-214.

Methods for Calculating Internal Radiation Exposures

At low dose rates, risk characterization for internal exposures to radionuclides (e.g., intake via inhalation or ingestion) is calculated as follows:

$$ILCR_{r,i} = (Intake_{r,i}) \bullet (SF_{r,i}) \qquad \text{Eq. A.5-1}$$

where:

$ILCR_{r,i}$ = incremental lifetime cancer risk, expressed as a unitless probability, for radionuclide "i" via exposure route "r"

$Intake_{r,i}$ = intake for radionuclide "i" via exposure route "r" (pCi)

$SF_{r,i}$ = cancer slope factor for radionuclide "i" via exposure route "r" (pCi^{-1})

Methods for Calculating External Radiation Exposures

Risk characterization for external exposure to gamma-emitting radionuclides in contaminated surface soil is calculated as follows:

$$ILCR_{ext,i} = (A_{ext,i}) \bullet (SF_{ext,i}) \qquad \text{Eq. A.5-2}$$

where:

$ILCR_{ext,i}$ = incremental lifetime cancer risk, expressed as a unitless probability

$A_{ext,i}$ = time integrated activity concentration of radionuclide "i" (pCi-y/g)

$SF_{ext,i}$ = cancer slope factor (external) of radionuclide "i" (g/pCi-y)

The time integrated activity parameter is described in A.3.4.1.3 (Eq. A.3-5).

A.5.1.1.2 Chemocarcinogenic Risks

Method for Calculating Carcinogenic Risk

At low doses, the ILCR for chemical carcinogens is determined as follows (EPA 1989a):

$$ILCR_{i,r} = (Intake_{i,r}) \bullet (SF_{i,r}) \qquad \text{Eq. A.5-3}$$

where:

$ILCR_{i,r}$ = incremental lifetime cancer risk, expressed as a unitless probability for chemical "i" via exposure route "r"
$Intake_{i,r}$ = intake for chemical "i" via exposure route "r" (mg/kg-day)
$SF_{i,r}$ = cancer slope factor of chemical "i" via exposure route "r" (kg-day/mg)

A.5.1.2 Toxic Effects

The risks associated with the toxic effects of noncarcinogenic hazardous chemicals are evaluated by comparing an exposure level or intake to a reference dose (RfD). The ratio of the intake to the RfD is called the hazard quotient (HQ) (EPA 1989a) and is defined as either:

$$HQ_i = \frac{Intake_i}{RfD_i} \qquad \text{Eq. A.5-4}$$

$$HQ_i = \frac{C_{m,i}}{RfC_{m,i}} \qquad \text{Eq. A.5-5}$$

where:

HQ_i = hazard quotient of chemical "i" (unitless)
$Intake_i$ = intake of chemical "i" (mg/kg/day)
RfD_i = reference dose of chemical "i" (mg/kg/day)
$C_{m,i}$ = concentration of chemical "i" in medium "m" (mg/m^3)
$RfC_{m,i}$ = reference concentration of chemical "i" in medium "m" (mg/m^3)

Chemical exposures were evaluated using chronic RfD values.

This approach is different from the approach used to evaluate carcinogens. An HQ of 0.01 does not imply a 1 in 100 chance of an adverse effect, but indicates only that the estimated intake is

100 times less than the RfD. An HQ of one (1) indicates that the intake is equal to the RfD. If the HQ is greater than 1, exposures to that chemical at detected concentrations are assumed to have the potential to cause adverse health effects.

A.5.1.3 Exposures to Multiple Constituents

Environmental media in Operable Unit 1 contain multiple chemical and radioactive constituents. For a given exposure pathway with simultaneous exposure of a receptor to several carcinogens, the following equation is used to sum cancer risks:

$$Risk_P = ILCR_1 + ILCR_2 + \ldots ILCR_i \qquad \text{Eq. A.5-6}$$

where:

Riskp = total risk of cancer incidence via pathway "p"
$ILCR_i$ = carcinogenic risk from chemical "i"

EPA guidance indicates that chemocarcinogenic and radiocarcinogenic risks may be summed for presentation, but cautions that the level of uncertainty in the cancer slope factors used to calculate these values are different (EPA 1989a). This baseline risk assessment presents the results of the chemical and radiological risk calculations separately as well as their sum totals to provide risk managers with a more complete understanding of potential human health risks from the site.

In the case of simultaneous exposure of a receptor to several noncarcinogens, a hazard index (HI) is calculated as the sum of the HQs by:

$$HI_p = HQ_1 + HQ_2 + \ldots + HQ_i \qquad \text{Eq. A.5-7}$$

where:

HIp = total hazard index via pathway "p"
HQ_i = hazard quotient from chemical "i"

A.5.1.4 Multiple Pathways

Multiple exposure pathways included in the conceptual model for the hypothetical receptors are evaluated in this assessment. The risks from various exposure pathways are assumed to be additive to a receptor receiving exposures from more than one pathway. Risks from multiple pathways are summed to determine the total risk to that receptor.

A.5.2 RISK ESTIMATES FOR CURRENT EXPOSURE CONDITIONS

As described in Section A.3.0, several hypothetical receptor populations are considered in the baseline risk assessment for current conditions. Only one receptor scenario was selected for quantitative evaluation. This scenario was selected because land-use restrictions limit plausible on-property receptors, and the scenario had the potential to produce the highest plausible exposures to an off-property receptor. All exposures addressed in this section are based on current conditions. This section and all following sections are organized around general risk summary tables that present total radiocarcinogenic risk and chemocarcinogenic risk, total carcinogenic risk, and HIs by media type for each receptor. Tables A.5-1 through A.5-3 present risks for each current receptor scenario assessed. There are no hazard quotients or hazard indices for the current receptor scenarios because no intakes occur for the current grounds keeper at the West Lake Landfill and there are no toxic chemical COPCs for the Ford property.

A.5.2.1 Current Exposure Scenarios for the Landfill

Current access controls and work practices prohibit general site workers and the public from entering Radiological Areas 1 and 2. Grounds keepers maintain the areas immediately adjacent to Areas 1 and 2 on a yearly basis. The only plausible exposure pathway that currently exists is direct radiation from the surface of Area 1 or 2 to workers at the perimeter of the area. It is important to note that the risks quantified for this exposure pathway are based on the simplifying and conservative assumption that the receptor is located at the center of an infinite slab of contaminated soil. These calculated risks are consequently much higher than the actual risk to a receptor at the perimeter of the area.

A.5.2.1.1 Hypothetical Grounds Keeper Adjacent to Area 1

Table A.5-1 presents the summary of risks for the grounds keeper scenario at the landfill at locations adjacent to Area 1 under current conditions. The calculated risk from all COPCs approaches 1×10^{-5}. This risk is within the generally acceptable EPA target risk range of 10^{-6} to 10^{-4}. The main contributors to this risk are radium-226 and its 5 daughters. External radiation exposure from radium-226 and its 5 daughters accounts for approximately 90% of the radiological risk.

Chemical carcinogenic risks and toxic effects do not occur for this scenario.

A.5.2.1.2 Hypothetical Grounds Keeper Adjacent to Area 2

Table A.5-2 presents the summary of risks for the grounds keeper scenario at the landfill at locations adjacent to Area 2 under current conditions. The calculated risk from all COPCs is approximately 4×10^{-5}. This risk is within the generally acceptable EPA target risk range of 10^{-6} to 10^{-4}.

External radiation exposure is the dominant exposure pathway for this scenario. Radium-226 and its 5 daughters contribute over 90% of the total risk.

Chemical carcinogenic risks and toxic health effects do not occur for this scenario.

A.5.2.2 Current Exposure Scenario for the Ford Property

The exposure pathways that currently exist are direct radiation exposure, soil ingestion, and dermal absorption. Table A.5-3 presents the summary of risks for the grounds keeper scenario on the Ford Property under current conditions. The calculated risk from all COPCs is approximately 6×10^{-7}. This risk is below the generally acceptable EPA target risk range of 10^{-6} to 10^{-4}.

There are no chemical COPCs for the Ford Property; therefore, potential risks are limited to the exposure to radionuclides. External radiation exposure is the dominant exposure pathway for this scenario. Approximately 84% of the total risk is attributable to radium-226 and its five daughters, and thorium-232 and its ten daughters.

A.5.3 RISK ESTIMATES FOR FUTURE EXPOSURE CONDITIONS

As described in Section A.3.0, hypothetical receptor populations are quantitatively evaluated in the baseline risk assessment for the future land-use scenarios. All exposures addressed in this section are based on the future source term, which is the current source term corrected for radionuclide ingrowth and decay, as appropriate.

A.5.3.1 Future Exposure Scenarios for the Landfill (Areas 1 and 2)

It is assumed that grounds keepers will provide on-site maintenance of Areas 1 and 2 on a yearly basis in the future. It is also assumed that an adjacent building user and a storage yard worker will spend some time on Areas 1 and 2 on a yearly basis in the future. The building will be located adjacent to but not on Areas 1 and 2 and portions of Areas 1 and 2 could be paved or graveled and used for parking and outdoor storage.

The exposure pathways that are currently evaluated for the landfill grounds keeper scenarios under future conditions are direct radiation exposure, soil ingestion, dermal adsorption, and inhalation. The exposure pathways and types of environmental media evaluated for the adjacent building user and the storage yard worker scenarios under future conditions are described in Section A.3.0. Tables A.5-4 through A.5-10 present risks for each future receptor scenario assessed. Table A.5-11 lists hazard quotients and hazard indices for the same future receptor scenarios. There are no hazard quotients or hazard indices for the adjacent building user or the storage yard worker scenarios because the paved or graveled parking lot/storage yard precludes all exposure pathways except direct radiation exposure.

A.5.3.1.1 Hypothetical Grounds Keeper on Area 1

Table A.5-4 presents the summary of risks for the hypothetical future grounds keeper for Area 1. The total calculated carcinogenic risk for the future grounds keeper for Area 1 from all COPCs and all pathways is 6×10^{-5}. This estimate is within the EPA target risk range of 10^{-6} to 10^{-4}.

The external radiation exposure pathway for radium-226 and its 8 daughters contributes approximately 80% of the total risk. Soil ingestion of radium-226 and its daughters, and inhalation of thorium-230 and protactinium-231 and its 8 daughters also contribute approximately 15% to the total risk. While direct radiation is the dominant pathway for this receptor, soil ingestion and inhalation are also potentially important pathways for future outdoor workers within Area 1.

Chemocarcinogenic risks contribute approximately 2×10^{-7} to the total risk. The HI of 0.0059 given in Table A.5-11 for the hypothetical grounds keeper in Area 1 indicates that no adverse toxic effects are expected for this receptor.

A.5.3.1.2 Hypothetical Grounds Keeper on Area 2

Table A.5-5 presents the summary of risks for the hypothetical future grounds keeper for Area 2. The total calculated carcinogenic risk for the future grounds keeper for Area 2 from all COPCs and all pathways is 2×10^{-4}.

The external radiation exposure pathway for radium-226 and its 8 daughters contributes over 90 % of the total risk. Soil ingestion of radium-226 and its daughters, inhalation of thorium-230, and external radiation exposure from protactinium-231 and its 8 daughters and thorium-232 and its 10 daughters combined contribute most of the remaining risk.

Combined chemocarcinogenic risks are approximately 3×10^{-8}. The HI of 0.0022 given in Table A.5-11 for the hypothetical grounds keeper in Area 2 indicates that no adverse toxic effects are expected for this receptor.

A.5.3.1.3 Hypothetical Adjacent Building User Parking on Area 1

Table A.5-6 presents the summary of risks for the hypothetical future adjacent building user for Area 1. The total calculated carcinogenic risk for the future adjacent building user for Area 1 from all COPCs and all pathways is 1×10^{-5}. This estimate is within the EPA target risk range of 10^{-6} to 10^{-4}.

The external radiation exposure pathway for radium-226 and its 8 daughters contributes over 90% of the total risk.

Chemocarcinogenic risks and toxic effects do not occur for this scenario because the only complete exposure pathway is exposure to direct external radiation.

A.5.3.1.4 Hypothetical Adjacent Building User Parking on Area 2

Table A.5-7 presents the summary of risks for the hypothetical future adjacent building user for Area 2. The total calculated carcinogenic risk for the future adjacent building user for Area 2 from all COPCs and all pathways is 4×10^{-5}. This estimate is within the EPA target risk range of 10^{-6} to 10^{-4}.

The external radiation exposure pathway for radium-226 and its 8 daughters contributes over 90 % of the total risk.

Chemocarcinogenic risks and toxic effects do not occur for this scenario because the only complete exposure pathway is exposure to direct external radiation.

A.5.3.1.5 Hypothetical Storage Yard Worker on Area 1

Table A.5-8 presents the summary of risks for the hypothetical future storage yard worker for Area 1. The total calculated carcinogenic risk for the future storage yard worker for Area 1 from all COPCs and all pathways is 1×10^{-4}.

The external radiation exposure pathway for radium-226 and its 8 daughters contributes over 90% of the total risk.

Chemocarcinogenic risks and toxic effects do not occur for this scenario because the only complete exposure pathway is exposure to direct external radiation.

A.5.3.1.6 Hypothetical Storage Yard Worker on Area 2

Table A.5-9 presents the summary of risks for the hypothetical future storage yard worker for Area 2. The total calculated carcinogenic risk for the future storage yard worker for Area 2 from all COPCs and all pathways is 4×10^{-4}.

The external radiation exposure pathway for radium-226 and its 8 daughters contributes over 90 % of the total risk.

Chemocarcinogenic risks and toxic effects do not occur for this scenario because the only complete exposure pathway is exposure to direct external radiation.

A.5.3.2 Future Exposure Scenario for the Ford Property

The exposure pathways and types of environmental media evaluated for the hypothetical future grounds keeper at the Ford property under future conditions, were identical to those for the current source-term conditions, with one exception. An inhalation pathway was added to the exposure pathways to reflect the uncertainty of future vegetative cover on the Ford property.

Table A.5-10 presents the summary of risks calculated for the hypothetical future grounds keeper for the Ford property under future conditions. The total calculated carcinogenic risk associated with radionuclides (there are no chemical COPCs for this area) and all pathways is 2×10^{-6}. This is somewhat higher than the calculated risk under current conditions, and is within the EPA target risk range of 10^{-6} to 10^{-4}.

The external radiation exposure pathway for radium-226 and its 8 daughters contributes over 90% of the total risk. Soil ingestion of radium-226 and its daughters and external radiation exposure from thorium-232 and its daughters contribute most of the remaining risk.

A.5.4 SUMMARY OF HEALTH RISK CHARACTERIZATION

The potential for health effects from exposure to site-related contaminants was estimated for receptors located on and off the landfill property. The discussion of the projected impacts is divided into those that may occur under either current conditions or assumed future conditions. Emphasis is given to the constituents that clearly dominate the assessment, and emphasis is given

to any receptor scenario producing risks in excess of EPA's remedial action objectives as stated in the NCP (EPA 1990b).

A.5.4.1 Summary of Health Risks Under Current Conditions

All receptor scenarios evaluated under current conditions produce risks that are within the target risk range of 10^{-6} to 10^{-4} (Table A.5-12). The maximum exposed individual for carcinogenic risks under these conditions is the grounds keeper working adjacent to Area 2. The cancer risk estimate for this receptor is 4×10^{-5}. The most important single contributor to this risk is external radiation from radium-226 and its short-lived daughters.

A.5.4.2 Summary of Health Risks Under Future Conditions

The grounds keeper, the adjacent building user, the storage yard worker for Areas 1 and 2, and the Ford property grounds keeper were evaluated under projected future conditions. The evaluation indicates that future receptors located off property (i.e., located on the Ford property) are not generally expected to be at risk from Areas 1 and 2, but activities on Areas 1 and 2 in the future have the potential to produce risks greater than 10^{-4} (Table A.5-13).

The maximum exposed individual for carcinogenic risks is determined to be the hypothetical future storage yard worker for Area 2. The cancer risk estimate for this receptor is 4×10^{-4} (Table A.5-13). This is due primarily to external radiation exposure from the continued ingrowth of radium-226 and its 8 daughters from the decay of thorium-230 over the 1000-year study period.

This calculated risk of 4×10^{-4} may be compared with the calculated lifetime risk of well over 10^{-2} from natural background radiation sources.

Nonradiological contaminants are not likely to cause an unacceptable risk to human health under future hypothetical conditions for any of the receptor scenarios evaluated. Additionally, adverse systemic (noncarcinogenic) health effects are not expected because all HIs are less than 1.

Table A.5-1 Calculated Incremental Lifetime Cancer Risks for the Landfill Grounds Keeper Scenario Adjacent to Area 1 - Current Conditions

Constituent	Exposure Route				
	Soil Ingestion	Inhalation	Dermal Absorption	Direct Radiation	All Routes
Uranium Series					
Uranium-238 + 2 dtrs	NE[a]	NE	NE	2 E-8	2 E-8
Uranium-234	NE	NE	NE	7 E-12	7 E-12
Thorium-230	NE	NE	NE	8 E-10	8 E-10
Radium-226 + 5 dtrs	NE	NE	NE	9 E-6	9 E-6
Lead-210 + 2 dtrs	NE	NE	NE	2 E-10	2 E-10
Actinium Series					
Uranium-235 + 1 dtr	NE	NE	NE	4 E-9	4 E-9
Protactinium-231+ 8 dtrs	NE	NE	NE	5 E-7	5 E-7
Thorium Series					
Thorium-232 + 10 dtrs	NE	NE	NE	3 E-7	3 E-7
Total Risks					
Radiocarcinogenic	NE	NE	NE	1 E-5	1 E-5
Chemocarcinogenic	NE	NE	NE	NE	NE

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

Table A.5-2 Calculated Incremental Lifetime Cancer Risks for the Landfill Grounds Keeper Scenario Adjacent to Area 2 - Current Conditions

Constituent	Exposure Route				
	Soil Ingestion	Inhalation	Dermal Absorption	Direct Radiation	All Routes
Uranium Series					
Uranium-238 + 2 dtrs	NE[a]	NE	NE	3 E-8	3 E-8
Uranium-234	NE	NE	NE	2 E-11	2 E-11
Thorium-230	NE	NE	NE	3 E-9	3 E-9
Radium-226 + 5 dtrs	NE	NE	NE	4 E-5	4 E-5
Lead-210 + 2 dtrs	NE	NE	NE	3 E-10	3 E-10
Actinium Series					
Uranium-235 + 1 dtr	NE	NE	NE	9 E-9	9 E-9
Protactinium-231+ 8 dtrs	NE	NE	NE	2 E-6	2 E-6
Thorium Series					
Thorium-232 + 10 dtrs	NE	NE	NE	1 E-6	1 E-6
Total Risk					
Radiocarcinogenic	NE	NE	NE	4 E-5	4 E-5
Chemocarcinogenic	NE	NE	NE	NE	NE

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

Table A.5-3 Calculated Incremental Lifetime Cancer Risks for the Landfill Grounds Keeper Scenario Ford Property - Current Conditions

Constituent	Exposure Route				All Routes
	Soil Ingestion	Inhalation	Dermal Absorption	Direct Radiation	
Uranium Series					
Uranium-238 + 2 dtrs	1 E-9	NE[a]	NE	2 E-9	3 E-9
Uranium-234	8 E-10	NE	NE	8 E-13	8 E-10
Thorium-230	1 E-8	NE	NE	3 E-11	1 E-8
Radium-226 + 5 dtrs	6 E-9	NE	NE	3 E-7	3 E-7
Lead-210 + 2 dtrs	7 E-8	NE	NE	2 E-11	7 E-8
Actinium Series					
Uranium-235 + 1 dtr	4 E-11	NE	NE	5 E-10	6 E-10
Thorium Series					
Thorium-232 + 10 dtrs	1 E-8	NE	NE	2 E-7	2 E-7
Total Risk					
Radiocarcinogenic	1 E-7	NE	NE	5 E-7	6 E-7

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

Table A.5-4 Calculated Incremental Lifetime Cancer Risks for the Landfill Grounds Keeper Scenario Area 1 - Future Conditions

Constituent	Exposure Route				
	Soil Ingestion	Inhalation	Dermal Absorption	Direct Radiation	All Routes
Uranium Series					
Uranium-238 + 2 dtrs	1 E-8	2 E-8	NE[a]	2 E-8	5 E-8
Uranium-234	1 E-8	2 E-8	NE	7 E-12	3 E-8
Thorium-230	6 E-7	1 E-6	NE	8 E-10	2 E-6
Radium-226 + 8 dtrs	8 E-6	2 E-7 [b]	NE	5 E-5	6 E-5
Actinum Series					
Uranium-235 + 1 dtr	6 E-10	8 E-10	NE	4 E-9	5 E-9
Protactinium-231+ 8 dtrs	6 E-7	4 E-7	NE	5 E-7	1 E-6
Thorium Series					
Thorium-232 + 10 dtrs	3 E-8	3 E-8	NE	3 E-7	4 E-7
Inorganic Chemicals					
Arsenic	2 E-7	1 E-8	5 E-9	NE	2 E-7
Organic Chemicals					
Aroclor-1254	2 E-9	8 E-12	6 E-11	NE	2 E-9
Total Risk					
Radiocarcinogenic	1 E-5	2 E-6	NE	5 E-5	6 E-5
Chemocarcinogenic	2 E-7	1 E-8	5 E-9	NE	2 E-7

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

[b] Includes risks from inhalation of particulates and radon-222 gas

Table A.5-5 Calculated Incremental Lifetime Cancer Risks for the Landfill Grounds Keeper Scenario Area 2 - Future Conditions

Constituent	Exposure Route				
	Soil Ingestion	Inhalation	Dermal Absorption	Direct Radiation	All Routes
Uranium Series					
Uranium-238 + 2 dtrs	1 E-8	1 E-8	NE[a]	3 E-8	5 E-8
Uranium-234	1 E-8	2 E-8	NE	2 E-11	4 E-8
Thorium-230	7 E-7	2 E-6	NE	3 E-9	2 E-6
Radium-226 + 8 dtrs	1 E-5	3 E-7 [b]	NE	2 E-4	2 E-4
Actinum Series					
Uranium-235 + 1 dtr	6 E-10	8 E-10	NE	9 E-9	1 E-8
Protactinium-231+ 8 dtrs	9 E-7	6 E-7	NE	2 E-6	3 E-6
Thorium Series					
Thorium-232 + 10 dtrs	4 E-8	4 E-8	NE	1 E-6	1 E-6
Inorganic Chemicals					
Arsenic	2 E-8	1 E-9	5 E-10	NE	3 E-8
Lead	NS[c]	NS	NS	NE	-
Uranium	NS	NS	NS	NE	-
Organic Chemicals					
Aroclor-1254	2.0 E-9	1.0 E-11	9.0 E-11	NE	2.0 E-9
Total Risk					
Radiocarcinogenic	1 E-5	3 E-6	NE	2 E-4	2 E-4
Chemocarcinogenic	2 E-8	1 E-9	6 E-10	NE	3 E-8

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

[b] Includes risks from inhalation of particulates and radon-222 gas

[c] "NS" - Intake calculation is not applicable because EPA has not published a slope factor for use in quantifying the risk from this contaminant via this exposure route.

Table A.5-6 Calculated Incremental Lifetime Cancer Risks for the Landfill Adjacent Building User Scenario Area 1 - Future Condition

Constituent	Exposure Route					All Routes
	Soil Ingestion	Inhalation		Dermal Absorption	Direct Radiation	
Uranium Series						
Uranium-238 + 2 dtrs	NE[a]	NE	NE	NE	3 E-9	3 E-9
Uranium-234	NE	NE	NE	NE	1 E-12	1 E-12
Thorium-230	NE	NE	NE	NE	2 E-10	2 E-10
Radium-226 + 8 dtrs	NE	NE	NE	NE	1 E-5	1 E-5
Actinum Series						
Uranium-235 + 1 dtr	NE	NE	NE	NE	8 E-10	8 E-10
Protactinium-231+ 8 dtrs	NE	NE	NE	NE	1 E-7	1 E-7
Thorium Series						
Thorium-232 + 10 dtrs	NE	NE	NE	NE	7 E-8	7 E-8
Inorganic Chemicals						
Arsenic	NE	NE	NE	NE	NE	0 E+0
Organic Chemicals						
Aroclor-1254	NE	NE	NE	NE	NE	0 E+0
Total Risk						
Radiocarcinogenic	NE	NE	NE	NE	1 E-5	1 E-5
Chemocarcinogenic	NE	NE	NE	NE	NE	0 E+0

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

Table A.5-7 Calculated Incremental Lifetime Cancer Risks for the Landfill Adjacent Building User Scenario Area 2 - Future Condition

Constituent	Exposure Route					
	Soil Ingestion	Inhalation		Dermal Absorption	Direct Radiation	All Routes
Uranium Series						
Uranium-238 + 2 dtrs	NE[a]	NE	NE	NE	5 E-9	5 E-9
Uranium-234	NE	NE	NE	NE	4 E-12	4 E-12
Thorium-230	NE	NE	NE	NE	6 E-10	6 E-10
Radium-226 + 8 dtrs	NE	NE	NE	NE	4 E-5	4 E-5
Actinum Series						
Uranium-235 + 1 dtr	NE	NE	NE	NE	2 E-9	2 E-9
Protactinium-231+ 8 dtrs	NE	NE	NE	NE	4 E-7	4 E-7
Thorium Series						
Thorium-232 + 10 dtrs	NE	NE	NE	NE	3 E-7	3 E-7
Inorganic Chemicals						
Arsenic	NE	NE	NE	NE	NE	0 E+0
Uranium	NE	NE	NE	NE	NE	0 E+0
Organic Chemicals						
Aroclor-1254	NE	NE	NE	NE	NE	0 E+0
Total Risk						
Radiocarcinogenic	NE	NE	NE	NE	4 E-5	4 E-5
Chemocarcinogenic	NE	NE	NE	NE	NE	0 E+0

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

Table A.5-8 Calculated Incremental Lifetime Cancer Risks for the Landfill Storage Yard Worker Scenario Area 1 - Future Condition

Constituent	Exposure Route					
	Soil Ingestion	Inhalation		Dermal Absorption	Direct Radiation	All Routes
Uranium Series						
Uranium-238 + 2 dtrs	NE[a]	NE	NE	NE	3 E-8	3 E-8
Uranium-234	NE	NE	NE	NE	1 E-11	1 E-11
Thorium-230	NE	NE	NE	NE	2 E-9	2 E-9
Radium-226 + 8 dtrs	NE	NE	NE	NE	1 E-4	1 E-4
Actinum Series						
Uranium-235 + 1 dtr	NE	NE	NE	NE	8 E-9	8 E-9
Protactinium-231+ 8 dtrs	NE	NE	NE	NE	1 E-6	1 E-6
Thorium Series						
Thorium-232 + 10 dtrs	NE	NE	NE	NE	7 E-7	7 E-7
Inorganic Chemicals						
Arsenic	NE	NE	NE	NE	NE	0 E+0
Organic Chemicals						
Aroclor-1254	NE	NE	NE	NE	NE	0 E+0
Total Risk						
Radiocarcinogenic	NE	NE	NE	NE	1 E-4	1 E-4
Chemocarcinogenic	NE	NE	NE	NE	NE	0 E+0

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

Table A.5-9 Calculated Incremental Lifetime Cancer Risks for the Landfill Storage Yard Worker Scenario Area 2 - Future Condition

Constituent	Exposure Route				
	Soil Ingestion	Inhalation	Dermal Absorption	Direct Radiation	All Routes
Uranium Series					
Uranium-238 + 2 dtrs	NE[a]	NE	NE	5 E-8	5 E-8
Uranium-234	NE	NE	NE	4 E-11	4 E-11
Thorium-230	NE	NE	NE	6 E-9	6 E-9
Radium-226 + 8 dtrs	NE	NE	NE	4 E-4	4 E-4
Actinum Series					
Uranium-235 + 1 dtr	NE	NE	NE	2 E-8	2 E-8
Protactinium-231+ 8 dtrs	NE	NE	NE	4 E-6	4 E-6
Thorium Series					
Thorium-232 + 10 dtrs	NE	NE	NE	3 E-6	3 E-6
Inorganic Chemicals					
Arsenic	NE	NE	NE	NE	0 E+0
Uranium	NE	NE	NE	NE	0 E+0
Total Risk					
Radiocarcinogenic	NE	NE	NE	4 E-4	4 E-4
Chemocarcinogenic	NE	NE	NE	NE	0 E+0

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

Table A.5-10 Calculated Incremental Lifetime Cancer Risks for the Grounds Keeper Scenario Ford Property - Future Conditions

Constituent	Exposure Route				
	Soil Ingestion	Inhalation	Dermal Absorption	Direct Radiation	All Routes
Uranium Series					
Uranium-238 + 2 dtrs	1 E-9	3 E-10	NE[a]	2 E-9	3 E-9
Uranium-234	8 E-10	3 E-10	NE	8 E-13	1 E-9
Thorium-230	1 E-8	6 E-9	NE	3 E-11	2 E-8
Radium-226 + 8 dtrs	1 E-7	1 E-9 [b]	NE	2 E-6	2 E-6
Actinum Series					
Uranium-235 + 1 dtr	4 E-11	1 E-11	NE	5 E-10	6 E-10
Thorium Series					
Thorium-232 + 10 dtrs	1 E-8	4 E-9	NE	2 E-7	3 E-7
Total Risk					
Radiocarcinogenic	2 E-7	1 E-8	NE	2 E-6	2 E-6

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

[b] Includes risks from inhalation of particulates and radon-222 gas

Table A.5-11 Calculated Hazard Quotients and Hazard Index for All Future Scenarios

Constituent	Exposure Route[a]			
	Soil Ingestion	Inhalation	Dermal Absorption	Total
Area 1 Grounds Keeper				
Aroclor-1254	0.0004	NS	0.000017	0.0004
Arsenic	0.0053	NS	0.00012	0.0054
Total Hazard Index for Route	0.0057	NS	0.00013	
Total Hazard Index for Area 1 Grounds Keeper				**0.0059**
Area 2 Ground Keeper				
Aroclor-1254	0.00058	NS	0.000025	0.0006
Arsenic	0.0006	NS	0.000013	0.0006
Lead	NS	NS	NS	
Uranium	0.0010	NS	NS	0.0010
Total Hazard Index for Route	0.0021	NS	0.000038	
Total Hazard Index for Area 2 Grounds Keeper				**0.0022**

[a] Complete exposure pathways do not exist for the Adjacent Building User and the Storage Yard Worker.

[b] "NS" - Risk calculation is not applicable because no reference dose is available to quantify risk.

Table A.5-12 Summary of Risks for Current Receptor Scenarios Evaluated in the West Lake Operable Unit 1 Baseline Risk Assessment

	On-site		Off-site
Risks	Grounds Keeper Adjacent to Area 1	Grounds Keeper Adjacent to Area 2	Ford Property Grounds Keeper
Total Cancer Risks	1 E-5	4 E-5	6 E-7
Radionuclides	1 E-5	4 E-5	6 E-7
Chemicals	NE[a]	NE	NE
Hazard Index	NE	NE	NE

[a] NE - No exposure anticipated because a complete exposure pathway does not exist.

Table A.5-13 Summary of Risks for Future Receptor Scenarios Evaluated in the West Lake Operable Unit 1 Baseline Risk Assessment

	On-site						Off-site
Risks	Area 1 Grounds Keeper	Area 2 Grounds Keeper	Area 1 Adjacent Building User	Area 2 Adjacent Building User	Area 1 Storage Yard Worker	Area 2 Storage Yard Worker	Ford Property Grounds Keeper
Total Cancer Risks	6 E-5	2 E-4	1 E-5	4 E-5	1 E-4	4 E-4	2 E-6
Radionuclides	6 E-5	2 E-4	1 E-5	4 E-5	1 E-4	4 E-4	2 E-6
Chemicals	2 E-7	3 E-8	NE[a]	NE	NE	NE	NE
Hazard Index	0.0059	0.0022	NE	NE	NE	NE	NE

[a] "NE" - No exposure anticipated because a complete exposure pathway does not exist.

A.6.0 UNCERTAINTY ASSESSMENT

The purpose of the uncertainty assessment is to evaluate the potential impact of various input factors on the results of the risk assessment. This is accomplished by examining the basis of the risk assessment (i.e., assumptions, models, and numerical parameter values), estimating how they might vary, and qualitatively evaluating the impact on the results of the risk assessment.

A risk assessment contains two types of uncertainties - those uncertainties associated with a measured or estimated quantity or parameter value and those uncertainties associated with a lack of information. Measurement uncertainty refers to the usual variance that accompanies measurements (e.g., instrument measurement uncertainty, the number of samples collected, estimation of parameter values that describe processes, etc.). The uncertainties associated with measured values used to develop the results of the risk assessment accumulate in the uncertainty of the results. The uncertainties that stem from a lack of information, such as the absence of information on the effects of human exposure to a chemical or on the biological mechanism of action of an agent (EPA 1992d), may be significant in a risk assessment.

This risk assessment presents calculated risks for receptor exposure scenarios based on parameter values selected to yield risk estimates that are in the higher range of the distribution of risk but not greater than the highest risk. This represents a conservative (i.e., bias toward increasing health protectiveness) approach for assessing the potential risks from Operable Unit 1.

The remainder of this section addresses uncertainties of this risk assessment as they are derived from the following components of the risk assessment:

- Extent of radiologically-impacted material in Operable Unit 1,
- Characterization data for Operable Unit 1,
- Conceptual model for the assessment of risk from Operable Unit 1, and
- Calculation models and the numerical parameter values used for risk calculations.

A.6.1 Uncertainty Associated with the Extent of Radiologically-Impacted Material in Operable Unit 1

If the characterization data used to represent a site excluded site-related contamination, uncertainty would be introduced into the contaminant source term and ultimately into the exposure and risk assessment results. The magnitude of the uncertainty would depend on the extent of contamination excluded. The characterization data for Operable Unit 1 have been reviewed and used in the risk assessment in a manner to minimize this potential uncertainty. No site-related contamination was found to have been excluded from the source term. Operable Unit 1 consists of three areas of radiologically impacted materials at the West Lake Landfill: Area 1, Area 2, and a portion of the Ford property. Soil sampling locations for Operable Unit 1 include locations within Area 1 and Area 2 and additional soil sampling locations that lie outside of and adjacent to Area 1 and Area 2, including a portion of the Ford property. The analytical results for these adjacent locations were examined during the risk assessment to ensure that contaminant levels adjacent to Areas 1 and 2 were not overlooked in the risk assessment. Data for one of these adjacent locations (WL-105) were included with the Area 1 data due to the presence of thorium-230 contamination. Data for the Ford property were included in the risk assessment as a distinct data set. Table A.6-1 identifies this potential source of uncertainty, assigns a qualitative estimate of the relative impact (low in this case) on the Operable Unit 1 risk assessment results, and specifies whether the impact increases or decreases health protectiveness.

A landfill is likely to exhibit heterogeneity in its composition due to the variable nature of materials that are placed in landfills. This factor makes some aspects of the risk assessment more difficult to perform with certainty, such as the modeling of potential contaminant release routes. The modeling of radon release from the operable unit is a relevant example of a process that is impacted by uncertainty introduced by the heterogeneity of material present. The heterogeneity of landfill contents most likely introduces uncertainty in the results of the risk assessment that is biased toward increased health protectiveness, considering the biased sampling program included in the characterization effort. The corresponding potential impact identified in Table A.6-1 is high.

A.6.2 Uncertainties Associated with the Source Term for Operable Unit 1

As described in the EPA-approved work plan (McLaren/Hart 1994), 24 of the planned boring locations were selected as biased sampling locations and the remaining 26 planned boring

locations were selected using a stratified random sampling scheme. Selection of locations for biased soil borings was based on review of aerial photographs, radiological data collected previously, the need for perimeter groundwater monitoring well locations, and the results of the radiological survey. The selection of biased borehole locations introduces uncertainty in the Operable Unit 1 source term by increasing the representation of higher levels of contamination in the analytical data sets from which the Operable Unit 1 source term is derived. This selection process provides an extra measure of health protectiveness by attempting to ensure that higher levels of contamination are not missed. The potential impact of this uncertainty on the results of the risk assessment is high, as identified in Table A.6-1.

Measured concentrations of contaminants include the contribution of natural background contaminants. This is especially important for radionuclides in the three natural decay series that are the radiological COPCs in Operable Unit 1. Inclusion of the natural background concentrations of contaminants as part of the source term concentrations introduces a positive bias in the risks calculated for each receptor. The uncertainty introduced by this inclusion is considered to be moderate to low, as identified in Table A.6-1.

Uncertainty is introduced into the results of the risk assessment because of the variation among sample analytical results that comprise the source term data set for each contaminant. Each data set has a standard deviation associated with it, which increases as the range of results and variability among the results increases. The standard deviation and the mean of each data set are used to calculate the representative contaminant concentration (i.e., the 95% UCL) as described in Section A.3.0. Thus, uncertainty, in the form of these calculated statistical parameters, is introduced into the Operable Unit 1 source term. The calculated contaminant-specific UCL concentrations are in the higher range of the distribution of data and their use in the subsequent risk assessment calculations introduces a bias toward increased health protectiveness in the results of the risk assessment. This uncertainty is considered to be moderate, as identified in Table A.6-1.

A.6.3 Uncertainty Associated with the Risk Assessment Conceptual Model for Operable Unit 1

The conceptual model for Operable Unit 1 facilitates evaluation of the risks to human health by providing a framework for identifying exposure pathways by which human receptors may be

exposed to contaminants detected in Operable Unit 1. A conceptual model establishes a relationship between the following elements necessary to construct a complete exposure pathway:

- A source with potential constituents of concern,
- Contaminant release routes,
- Contaminant transport pathways, and
- A receptor exposure route at points of contamination.

The conceptual model was developed based on the commercial/industrial land use currently evident around Operable Unit 1 and the West Lake Landfill. Consideration was given to whether the current land use is likely to change. The degree of uncertainty associated with the conceptual model is, in part, proportional to the likelihood of change in land use. The current land use around Operable Unit 1 is commercial/industrial. The clear predominance of this land use is a strong argument for projecting its continuation into the future. More importantly, the restrictive covenants recorded against the West Lake Landfill, and against Areas 1 and 2 in particular, assure that Areas 1 and 2 will not be converted to a more sensitive land use in the future. These restrictive covenants can be amended only with the concurrence of the property owners, the MDNR, and the EPA. Selection of a commercial/industrial land-use scenario does not introduce uncertainty in the conceptual model for either the current or the future land-use scenario. Therefore, no uncertainty is contributed to the risk assessment by selection of the commercial/industrial land-use scenario for current and future time periods (Table A.6-1).

The conceptual model also includes consideration of appropriate receptor types for the assessment of individual risks. These receptor types are based on the predominant local commercial/industrial land use and the restrictive covenants recorded against the West Lake Landfill and against Areas 1 and 2 prohibiting residential use, groundwater use, excavation activities, construction of buildings, and installation of underground utilities or pipes on the property. Therefore, no uncertainty is contributed to the risk assessment by the selection of receptors for current and future time periods (Table A.6-1).

The Operable Unit 1 contaminant source term comprises three areas defined earlier. These three areas are considered potential sources of contamination in this risk assessment. Above-

background concentrations of radionuclides in Area 1 and Area 2 were found predominantly in the 0 and 5-foot samples, and less frequently in deeper samples. Above background concentrations of radionuclides on the Ford property were all within the set of surface soil sample data with the exception of one sample location (WL-206). Radionuclide levels decrease significantly with depth, indicating contamination is reasonably close to the surface. Potential releases from Operable Unit 1 that were initially considered in the risk assessment include release of contaminated soil, surface water, sediment, groundwater, VOCs, radon gas, and penetrating gamma radiation. The potential routes of release are described in Section A.3.0, with an evaluation of the applicability of each route to potential receptors. The Operable Unit 1 characterization data do not indicate that contaminants have been released from Operable Unit 1, with the exception of the soil sample results for a portion of the Ford property. Radon releases to outdoor air are expected from the future radium-226 concentrations that will accumulate as thorium-230 decays to radium-226. Estimates of potential future radon releases are made using the RAECOM radon emission model (NRC 1984). Uncertainty is introduced by the use of the RAECOM model, designed for modeling releases from mill tailings and cover soil, to model release from landfill materials, which are likely to be heterogeneous and only partially comprised of soil. However, once released, the radon will be diluted to naturally-occurring levels. Coupled with the access limitations provided by the restrictive covenants, this will reduce the impact of the radon modeling uncertainty on the risk assessment. Based on the discussion of release routes above and in Section A.3.0, uncertainties associated with potential source release routes and environmental transport mechanisms are considered low (Table A.6-1).

The exposure assessment in Section A.3.0 initially considers potential exposure of a variety of receptors. Complete exposure routes do not exist for some of the receptors initially considered; therefore, those routes are eliminated from the quantitative risk assessment process. In some cases the exposure route is incomplete because it lacks a reasonable route for receptor exposure at a point of contamination. For example, receptors located in the vicinity of Operable Unit 1 would not reasonably rely on local groundwater to supply their water consumption needs considering the presence of an abundant supply of high quality municipal water. The availability of the municipal water can be expected to continue in the future. Thus, even if the groundwater were impacted by contaminant migration from Operable Unit 1 in the future, it is not reasonable to hypothesize a receptor exposure route using the groundwater instead of the available municipal water supply. Another example concerns the restrictive covenants associated with the West Lake Landfill, which preclude residential use, groundwater use, excavation activities,

construction of buildings, and installation of underground utilities or pipes on the property. The restrictions preclude exposures of the hypothetical on-site residents, construction workers, or building occupants. Because of considerations such as the availability of municipal water and restrictive covenants against the property, uncertainties associated with the potential receptor exposure routes considered and quantitatively assessed in the risk assessment are considered low (Table A.6-1).

A.6.4 Uncertainty Associated with the Risk Calculation Models and the Numerical Values Used in Risk Calculations

Exposures are quantified using the general methodology prescribed by the EPA for CERCLA risk assessments (EPA 1989a). Receptor intakes are calculated consistent with the EPA methodology for estimating exposure (EPA 1989a) using arithmetic expressions and specific numerical parameter values defined for Operable Unit 1 in the exposure assessment. The calculation steps and numerical parameter values are described in Section A.3.0.

The calculation expressions are simplifications of processes that are actually more complex, introducing uncertainty. It is likely that the expressions specified in the EPA methodology (EPA 1989a) overestimate rather than underestimate potential exposures in the interest of conservatism. The level of potential impact of this uncertainty on the results of the risk assessment is considered to be moderate to high (Table A.6-1).

Uncertainties in the parameter values used in exposure calculations introduce corresponding uncertainties in the results of the risk assessment. In the arithmetic expressions that model exposure, most of the parameter values are used in a multiplicative manner such that variations in a parameter value cause a proportional variation in the calculated exposure. Thus, uncertainties in individual parameter values have a low to moderate impact on the results of the risk assessment. However, the impact of simultaneous variations in multiple parameters in the same direction of bias can substantially impact the results of the risk assessment. An awareness of the potential for this effect is important during the process of selecting individual parameter values for each receptor exposure pathway. This risk assessment presents risk results that are in the higher range of the distribution of risk but not greater than the highest risk. Thus, these results present a health protective estimate of the risks from the hypothetical exposure conditions.

Each risk calculation includes a term that represents the toxicity of the contaminant to which the receptor is exposed. Toxicity values are single-point values derived from data describing the relationship between exposure and the associated health impact (i.e., cancer risk or threshold effect). Uncertainties associated with each carcinogenic risk slope factor and each non-carcinogenic reference dose value depend on how accurately the data set used to derive the toxicity value represents the actual relationship in humans and the magnitude of uncertainty factors built into toxicity values in the interest of health protectiveness. Frequently, the amount of toxicity data available for deriving toxicity values is very limited, introducing considerable uncertainty.

There are many sources of uncertainty in the dose-response evaluation for carcinogenic effects (i.e., calculation of a slope factor) and for non-carcinogenic effects (e.g., calculation of a reference dose or reference concentration). These include:

- The uncertainty of extrapolation from animal studies to effects in humans, which, in the absence of pharmacokinetic, dosimetric, or mechanistic data, is based on consideration of differences in basal metabolic rate. The actual toxicity in humans may be higher or lower than suggested by the animal study data. As a health protective measure it is usually assumed that the toxicity is greater in humans than would be estimated based on the animal study data.

- The uncertainty of variation among individuals. Most toxicity studies are performed with animals that are similar in age and genotype, so that biological variation between individuals is minimized. In contrast, the human population may exhibit much heterogeneity including unusual sensitivity to contaminants.

- The uncertainty arising from the quality of the key study from which the quantitative relationship is derived.

- The uncertainty for non-carcinogenic effects arising from the use of a level of effect in estimating reference doses and reference concentrations, assuming that a threshold exposure exists below which no effect occurs.

- The uncertainty arising when reference doses or reference concentrations are estimated for chronic exposure based on data that do not represent chronic exposure.

- The uncertainty arising from the fact that reference doses, or reference concentrations, do not exist for all of the contaminants in this risk assessment. The potential effects associated with

these contaminants could not be quantitatively evaluated. This results in an underestimation of potential systemic health effects.

- Radionuclide slope factors include uncertainties from biokinetic models, dosimetry models, dose response extrapolation models, and vital statistics and mortality data.

The overall potential impact on the results of the risk assessment contributed by the uncertainties inherent in contaminant toxicity values (slope factors and reference doses) used to quantify risks is considered high (Table A.6-1) in light of the safety factors incorporated into these values in the interest of protectiveness of human health.

EPA external exposure slope factors in HEAST were used to calculate the direct radiation risks. These slope factors assume the individual is standing on an infinite slab of contamination. A grounds keeper working on the edge of a finite area (i.e., for the current grounds keeper cutting grass adjacent to Area 1 or 2) would actually be exposed to less radiation than the same individual standing on an infinite slab. Therefore, the use of the EPA slope factors for this receptor results in an overestimation of risk from this combination of receptor, exposure route, and source geometry. The potential impact on the results of the risk assessment is considered moderate (Table A.6-1).

Each exposure calculation includes a term that represents the concentration of contaminant to which the receptor is exposed. Uncertainties associated with the representative contaminant concentrations used to estimate receptor exposures introduce corresponding uncertainties in the results of the risk assessment. The magnitude of the uncertainty depends on how accurately the data set used to derive the exposure point concentration represents actual exposure point concentrations (i.e., the representativeness of sampling, direction of any bias in the sampling, and sample size) and the level of precision associated with the data set (i.e., the standard deviation of the sample set, sample size, and the assignment of data qualifiers in the data set). Non-radiological analytical results with associated data qualifiers are used at the numerical level reported. There is considerable uncertainty in the representative concentrations calculated for non-radiological contaminants because of the limited number of samples and the sparse number of detections. In consideration of these types of uncertainties, the risk assessment uses calculated 95% UCL concentrations, which, in the interest of health protectiveness, are in the higher range of the distribution contaminant concentrations. The potential impact on the results of the risk assessment is considered moderate (Table A.6-1).

A.6.5 Summary of Uncertainty Assessment

Use of the numerical results of the risk assessment without consideration of uncertainties, limitations, and assumptions inherent in the risk assessment process can be misleading. For example, a 10^{-6} lifetime risk of cancer may be calculated for an individual from exposure to a particular source of contamination. However, if the uncertainty in this result is several orders of magnitude, the risk from this source of contamination may in fact be higher than another 10^{-4} calculated lifetime risk of cancer with a small degree of uncertainty. Alternatively, a 10^{-2} calculated lifetime risk may appear to represent an unacceptable risk. However, the risk may be orders of magnitude smaller. This situation may arise when the estimated risk is based on limited information, uncertainty in the calculational parameters, conservative assumptions on lifestyles and land-use scenarios, and use of parameter values that are in the higher range of the distribution of data for many exposure parameters to ensure that the risks are not underestimated. The results of the risk assessment for Operable Unit 1 are based on such conservatism. Although it is possible that such an exposure, dose, or sensitivity combination might occur in a given population of interest, the probability of an individual actually being exposed to this combination of events and conditions is considered low.

The risk characterization step of the risk assessment process combines the uncertainties of the exposure assessment and the toxicity assessment, propagating those uncertainties in the results of the risk assessment. Additional uncertainty is introduced in the results by the summation of contaminant- or route-specific cancer risks (or HQ values) to obtain a total estimate for a given medium of exposure. The toxicity of a group of contaminants is generally additive only if the contaminants act on the same target organ. The assumption that contaminants affect the same target organ is conservative, which is likely to overestimate potential risks. Similarly, cancer risk results that address route-specific exposure pathways (i.e., oral ingestion risks versus inhalation risks) are generally added together in a risk assessment. The addition of pathway-specific risk results is also a conservative approach, which is likely to overestimate potential risk to a receptor.

The overall impact on the results of the risk assessment from the various uncertainties discussed in this section can be qualitatively determined by examining Table A.6-1. The table clearly indicates that the overall impact of the uncertainties is to increase health protectiveness.

Similarly, note that all of the uncertainties estimated to have a moderate or high potential impact, except one, are considered to increase health protectiveness. Although it is possible that the conservative exposure and risk hypothesized in the risk assessment might occur in a given population of interest, the probability of an individual actually being exposed at these risk levels is considered low.

Table A.6-1 Uncertainties Associated with Estimated Risks for Operable Unit 1

Section	Source of Uncertainty	Potential Impact on Estimated Risks	Impact on Health Protectiveness
6.1	Extent of Operable Unit 1 Areas	Low	Increases protectiveness
	Heterogeneity of waste form	High	Increases protectiveness
6.2	Bias in sampling	High	Increases protectiveness
	Inclusion of natural background concentrations	Low to Moderate	Increases protectiveness
	Calculation of 95% UCL	Moderate	Increases protectiveness
6.3	Current and future land use as commercial/industrial	None	None
	Current and future receptors occupational	None	None
	Source release and environmental transport mechanisms	Low	None
	Radon release model	Low	Increases protectiveness
	Future receptor exposure mechanisms at points of contamination	Low	None
6.4	Approximating exposure with simplified expressions	Moderate to high	Increases protectiveness
	Change in individual parameter values	Low to moderate	Generally increases protectiveness
	Slope factors and reference doses	High	Increases protectiveness
	No reference doses for some contaminants	Moderate to high	Decreases protectiveness
	External exposure source geometry	Moderate	Increases protectiveness
	Representative contaminant concentrations	Moderate	Increases protectiveness

A.7.0 ECOLOGICAL RISK ASSESSMENT

The purpose of an ecological risk assessment (ERA) is to evaluate the potential for adverse ecological effects associated with exposure to chemicals in environmental media. This screening-level risk assessment will address the potential risks associated with exposure of ecological receptors to both radiological and chemical contaminants present in Operable Unit 1.

The ERA was conducted in accordance with the available guidance documents (EPA 1992f, 1996b, 1997d). EPA *ECO Update* bulletins (EPA 1992g and 1992h) and publications (e.g., Maughan 1993, Suter 1993, Calabrese and Baldwin 1993, Wentsel et al. 1996, and Sample et al. 1997). For the purposes of this ERA, "Area 2" includes all of Area 2 and the adjacent Ford property. The habitats present within Area 2 and the Ford property are similar with no ecological division between the two properties. Therefore, the same ecological receptors are likely to be present at both.

The risk assessment is structured according to the following general framework (EPA 1997d):

- Problem formulation,
- Exposure assessment,
- Effects assessment,
- Risk characterization, and
- Uncertainty analysis.

A.7.1 PROBLEM FORMULATION

Problem formulation is the first step in an ERA and establishes the goals, breadth, and focus of the risk assessment (EPA 1997d). This phase provides the information that forms the basis of the risk assessment and includes: a description of the ecosystems present, the relationship of the on-site ecological receptors to the surrounding areas, the chemicals of potential concern (COPCs), analysis of potential exposure pathways for ecological receptors, and the identification of the assessment and measurement endpoints that will be evaluated. This information is integrated into the ERA conceptual model that describes how a given chemical may affect the various ecological components being evaluated (EPA 1997d).

The following description of problem formulation for Operable Unit 1 includes the following:

- Biological characterization (Section A.7.1.1),
- Identification of chemicals of potential concern (Section A.7.1.2),
- Identification of exposure pathways (Section A.7.1.3),
- Selection of assessment endpoints (Section A.7.1.4), and
- Development of the West Lake Landfill conceptual model (Section A.7.1.5).

A.7.1.1 Biological Characterization

This biological characterization identifies the major ecological habitats located on or near the West Lake Landfill and the potential ecological receptors either directly observed or identified from distinctive signs (tracks, droppings, burrows, etc.). McLaren/Hart also requested federal and state listings of threatened and endangered species from the U. S. Fish and Wildlife Service and from the Missouri Department of Conservation (McLaren/Hart 1996f). Ecological surveys were conducted by McLaren/Hart (McLaren/Hart 1996f). Survey activities included mapping vegetation communities in Areas 1 and 2, and walkovers of the West Lake Landfill identifying the various types of wildlife and plants present.

A.7.1.1.1 Plant Communities

Types of vegetation found in Area 1, Area 2 (exclusive of the Ford property), the Ford property and in two adjacent areas are listed in Table A.7-1. The types of plant communities are important in determining what wildlife species are likely to inhabit or frequent these areas. A description of vegetation is provided for Areas 1 and 2 and the surrounding areas.

Area 1 Area 1 is completely vegetated. The vegetation in Area 1 consists predominantly of old field community interspersed with six small depressions dominated by hydrophillic vegetation. The old field community consists primarily of grasses (bluestem, foxtail, and various other species) and various herbaceous species, predominantly goldenrod, nodding thistle and curled dock, in addition to common plantain and field pennycress. No woody species were observed to be dominant.

The hydrophillic plant communities were present in small surface depressions in the landfill that are likely the result of differential landfill subsidence over time, and the resultant poor surface drainage caused surface runoff to collect in these depressions. The hydrophillic plant

communities are dominated by herbaceous vegetation such as rushes, curled dock, and cattails. A green algae, *Spirogyra* spp., was also present in two areas with standing water.

Operable Unit 1 is bordered on three sides by areas that were formerly used as a landfill. The entrance road borders the northern portion of Area 1 at the West Lake Landfill. The area to the east extending from Area 1 to the edge of the West Lake Landfill is covered by old field vegetation. The land west and south of Area 1 was recently graded and seeded with grass. Currently these areas are not vegetated.

Area 2 Approximately 50 to 70 percent of Area 2 is covered by vegetation. The areas located in the southwestern portion of Area 2 have scattered vegetative cover. These areas were formerly used for the storage of gravel and crushed stone. Remnants of this material can be clearly seen on the surface. The rocky soil provides a poor medium for plant growth. Therefore, the absence of vegetation is likely to be a result of the rocky soils present. Area 2 plant communities include an old field community, a forested berm area dominated by woody vegetation and small isolated hydrophilic communities containing cattails and other hydrophilic species. The old field plant community is the dominant plant community covering the majority of the West Lake Landfill surface between the berm on the north and west margins of this area and the active operations located to the east and south of this area. The old field community in Area 2 is dominated by invasive herbaceous species such as nodding thistle, yellow sweet clover and goldenrod. Various grass species are also present. Woody species noted to be present include numerous young stands of staghorn sumac and eastern cottonwoods.

The berm along the north and west boundaries of Area 2 contains a forest plant community. This community is dominated by woody species including eastern cottonwood, willows, dogwoods and ash trees. A species of grape was the dominant vine present. Bedstraw and other old field species are present along the edge habitat between the forest community and the old field community.

Ten small isolated areas contain plant species typical of hydrophilic communities. In most of these areas, cattails were the dominant species present. These areas appear to be small depressions presumably the result of differential settlement in the landfill, which collect surface water runoff.

The Ford property, to the north, consists of an old field community. This area is has not been farmed since the 1980's. Dominant plant species in this area include nodding thistle, goldenrod, daisy fleabane, yellow sweet clover, and various grasses.

Surrounding Areas The vegetation surrounding the north surface water body consists of a forest-type community that is a continuation of the adjacent plant community located on the landfill berm on the north and west margins of Area 2. This plant community consists of a dense canopy cover and under-story, which includes eastern cottonwoods, ashes, dogwoods, and willows.

A drainage ditch is located along the northern boundary of the West Lake Landfill along the edge of St. Charles Rock Road. The slope of the berm between the fence and the drainage ditch is covered by a maintained field. The ditch is not well defined and is heavily vegetated. Various grasses, herbaceous plants and small tree saplings are growing along the drainage ditch.

The area surrounding the West Lake Landfill is developed. Two ecosystems in the area include the south flood control channel and a small forested area adjacent to the southwest section of the landfill. The south flood control channel is located west of the West Lake Landfill and is associated with the Earth City development. The south flood control channel consists of well-defined, man-made bed and banks. The shores of the flood control channel consist of a maintained lawn.

A small wooded area is located next to the southwest corner of the West Lake Landfill, but is not adjacent to either Area 1 or 2. Vegetation present is typical of an Eastern Deciduous forest and is approximately 5 to 10 acres in size. This area was larger at one time but recent development of the area has eliminated significant portions of forested areas.

A.7.1.1.2 Wildlife

Numerous species of wildlife were noted during the biosurvey activities. Deer tracks (*Odocoileous spp.*) were noted in Areas 1 and 2. Given the home range of deer, it is likely that the deer inhabit and graze the wooded area southwest of the West Lake Landfill. Given the shrinking amount of forested area in the vicinity of the landfill and the absence of vegetation

over much of the West Lake Landfill, these animals are likely to be forced out of the area in the near future. Activities on the adjacent commercial/industrial properties will drive the deer away.

Rabbits (*Sylvilagus floridanus*) and signs of rabbits were observed in Areas 1 and 2 and the drainage area including the north surface water body. These animals nest in areas where heavy brush, bushes, hedges, etc. are present to provide cover. Therefore, the nesting habitat within the West Lake Landfill would be limited to Areas 1 and 2 and areas along portions of the berm and in the drainage area.

Several droppings containing fur were observed in Areas 1 and 2 and a relatively large den was observed in the berm of Area 2. These droppings and the presence of a den, were possibly due to coyotes (*Canis latrans*), red fox (*Vulpes vulpes*) or possibly both. The home range of these species is large enough to include the entire West Lake Landfill. The presence of rabbits suggests a food source for these species within their home range.

Birds observed in the area included red-winged black birds (*Aeqlaius phoeniceus*), robins (*Turdus migratorius*), and, occasionally, crows (*Corvus brachynchos*). Other passerine birds are likely to be present at the West Lake Landfill. A great blue heron (*Ardea herodias*), a piscivorous bird, was observed flying above the West Lake Landfill and landing in the south flood control channel. This species may visit the West Lake Landfill, but it is unlikely that this bird would be chronically exposed to chemicals during his visit. This bird will be attracted to areas with waters containing fish and amphibians. The only area at the West Lake Landfill that may attract such birds is the north surface water body. However, there are no fish in this area, although amphibians are likely to be present; the pond is sometimes dry; and it is located adjacent to a major highway. Given the absence of desirable habitat, exposure of this bird would be sporadic, if at all.

The habitat present at Areas 1 and 2 is favorable for reptiles. A survey for reptiles did not find any snakes; however, snakes have been observed by workers (McLaren/Hart 1996f).

The north surface water body is a shallow pond covering less than 0.25 acres. The pond varies in size and may become dry during periods of drought or low precipitation. It is unlikely that the

pond would support fish. Aquatic populations that may be present would include invertebrates, especially aquatic insects, and amphibians.

A.7.1.1.3 Future Changes in Current Ecosystems

The current early field succession plant communities present in Areas 1 and 2 are attributable to the lack of mowing and other maintenance operations associated with restricted access to the areas. Normal maintenance operations would involve periodic mowing of these areas to prevent field succession from occurring. The areas within the landfill that are adjacent to these sites, are either maintained grasses or have been graded and reseeded.

As part of landfill closure activities, a maintainable vegetative cover would likely be established and maintained. Therefore, the current plant communities present are likely to represent the "climax" community because further successional development of these plant communities would compromise the integrity of the landfill cover.

The area surrounding the West Lake Landfill is rapidly being developed. Current habitats in the surrounding areas are likely to be destroyed through ongoing commercial/industrial development of the area. The diversity of ecological habitats in the area are likely to decrease in the near future.

The drainage ditch and the area surrounding the north surface water body will likely remain undisturbed. Also, periodic maintenance operations will limit the extent of development of trees along the drainage ditch. The area surrounding the north surface water body may undergo further successional changes; however, this area is less than 0.5 acre and would not support a large wildlife population.

In the future, as the areas surrounding the West Lake Landfill undergo additional commercial/industrial development, the diversity of wildlife habitat and the relative size of suitable habitats is likely to decrease. Habitats within Operable Unit 1 will also decrease once normal maintenance operations resume and the area is mowed and maintained as a grassy area. The current conditions reflect an ecological climax community in terms of its diversity and the size of the wildlife habitat present.

A.7.1.1.4 Endangered Species

Based on the results of the ecological studies, no federal threatened, endangered, or state-listed species are likely to inhabit the two areas (McLaren/Hart 1996f).

A.7.1.2 Identification of Chemicals of Potential Concern

For identification of chemicals of potential concern, the ERA used data from the Soil Boring/Surface Soil Investigation Report, West Lake Landfill Areas 1 and 2 (McLaren/Hart 1996b). All chemicals and radionuclides detected at least once in the appropriate environmental media were evaluated as potential COPCs. Metals and some radionuclides are naturally occurring, therefore, the maximum concentration detected was compared with natural background screening values to determine if the concentrations present were the result of site-related activities. All organic compounds detected were selected as COPCs. The maximum concentrations of inorganic compounds in soils were compared with natural background concentrations; those exceeding natural background concentrations also were retained as COPCs.

The potential risks associated with exposure to chemicals are different from those associated with exposure to radionuclides. Potential risks associated with exposure to chemicals are limited to systemic toxicity or damage to an organ or organ system as a result of the chemical interactions. Risks associated with exposure to radionuclides include effects associated with radiation exposure and systemic effects resulting from the chemical toxicity of the radionuclide.

The COPCs to be evaluated for chemical toxicity included all chemicals detected above background and the total radionuclides. Uranium was the only radioactive element identified in Operable Unit 1 with sufficient toxicological data available to address its systemic toxicity. Therefore, this was the only radioactive element included in the list of chemical COPCs. The potential risks associated with exposure to radiation will be addressed as the total cumulative exposure as compared to exposure from each individual radionuclide (Section A.7.4.2, Characterization of Radiological Risks). Because radionuclides are not addressed individually, a list of radionuclides of potential concern is not presented.

COPCs were selected for each environmental medium (i.e., surface soils, near-surface soils, surface water, and groundwater). For the purposes of evaluating risks to terrestrial ecological receptors, soil samples were grouped as surface samples (i.e., 0-1 foot samples) and near surface

samples (5-feet samples) for evaluation. Larger burrowing animals (e.g., red fox and rabbits) often excavate burrows which extend down to 4 feet (Rue 1969). Soil samples taken from depths greater than 5 feet were excluded because it is unlikely that ecological receptors would come into contact with contamination at depths greater than 5 feet. The COPCs for surface soils are given in Table A.7-2.

The COPCs for surface water were selected from those chemicals detected in runoff water and the north surface water body. The contaminants detected in the seep are addressed as groundwater. The COPCs for surface waters are listed in Table A.7-2.

Contaminants in groundwater are generally isolated from ecological receptors unless groundwater discharges to a surface water body. Perched groundwater in the landfill discharges to the surface via a seep located in the southwest corner of Area 2. Offsite migration in the alluvial aquifer has not been demonstrated and the potential for migration appears to be limited (Section 7, EMSI 1998). Further discussion of groundwater migration is given in Section 7.1.3.1 (Migration Pathways). The COPCs for groundwater are limited to those chemicals detected in the seep, which may be a source of exposure for wildlife.

A.7.1.3 Identification of Exposure Pathways

In order for a chemical to pose an ecological risk, it must reach ecological receptors in biologically significant concentrations. An exposure pathway is the means by which a contaminant moves in the environment from a source to an ecological receptor. For an ecological exposure pathway to be complete, it must have a contaminant source, a release mechanism, an environmental transport medium, a point of exposure for ecological receptors, and a feasible route of exposure. Only complete exposure pathways will be assessed in the ERA. Rationale will be provided to support the elimination of any pathways from further consideration.

The migration pathway analysis addresses release and migration of contaminants in the environment, describing what potential migration pathways exist at the site and the types of environmental media likely to be impacted. The exposure pathway analysis addresses whether an ecological receptor is likely to come into contact with contaminants present in an environmental medium (i.e., a point of exposure) and the likely routes of exposure such as:

ingestion, inhalation, or dermal contact.

A.7.1.3.1 Migration Pathways

Soil is the primary source of contamination in Areas 1 and 2. Contaminants in soils may be released in the environment via leaching, dissolution into surface water, erosion into runoff water, volatilization, and wind erosion. Each of these potential release mechanisms and the associated migration pathways are evaluated below.

Contaminants present in surface and near-surface soils may leach into subsurface soils and potentially into groundwater. Groundwater generally was not encountered within the landfill deposits. Continuous groundwater generally occurs only in the underlying alluvium at or below the base of the landfill materials and in the bedrock formation. The only exception is the presence of localized zones of perched water within the landfill deposits. Analysis of the water level data indicates that generally there are no strong horizontal or vertical gradients within the alluvium aquifer. The water table beneath the landfill area can best be described as extremely flat with little variation or relief. The exception is the depression in the water table associated with the ongoing leachate extraction at the active sanitary landfill. There is generally little, if any, vertical hydraulic gradient present within the alluvium beneath the landfill.

Given the overall flat nature of the water table beneath the landfill, exact determinations of the directions of groundwater flow are difficult. Based on the water level data, the general direction of alluvial groundwater flow in the vicinity of the landfill appears to be to the north, parallel to the river valley and the general direction of river flow in this area. However, localized variations to this general direction of groundwater flow do exist beneath the landfill as a result of influences upon localized groundwater flow. For example, groundwater flow beneath Area 1 appears to occur primarily in a southern direction toward the active landfill. This flow direction appears to be in response to the pumping associated with the leachate collection system at the active sanitary landfill. Groundwater flow beneath Area 2 is generally to the north-northwest, consistent with the overall regional flow direction.

Exposure to ecological receptors will not occur unless groundwater discharges to the surface. There is a seep located in the northwest corner of Area 2 immediately above the Ford property. Water discharges from the seep only following significant rain events; therefore, the water

discharging from the seep represents perched groundwater and not water from the alluvial aquifer. The groundwater within the alluvial aquifer is not migrating toward any nearby surface water bodies.

Chemicals may migrate via runoff (i.e., becoming entrained in surface water runoff from rain events) and soil erosion. This would result in the spread of surface chemicals in surface soils on Operable Unit 1 and, possibly, to surrounding areas. Analysis of surface water runoff from Area 1 indicates that chemicals are migrating via runoff and soil erosion. Surface water runoff from this area flows to a drainage ditch along the northern boundary of Area 1 and feeds into another drainage ditch adjacent to St. Charles Rock Road, ending in the north surface water body. Contaminants present in these surface waters are a potential source of exposure to wildlife.

Soils deposited as sediment in the drainage ditches may also be a source of exposure for animals. The drainage ditch located within the West Lake Landfill has been excavated to provide better drainage. Therefore, potential contaminants that were present in this ditch are likely to have been removed. The drainage ditch along St. Charles Rock Road is heavily vegetated. This vegetation would prevent the transport of particulates; thus, particulates are not expected to be transported beyond the beginning of this ditch. Therefore, the amounts of chemicals present in the drainage areas is expected to be insignificant. Chemical runoff from Area 2 is generally limited to Area 2 and the areas immediately adjacent to Area 2 (including the Ford property).

Volatilization of chemicals from soil may result in the release of chemicals into the air or into the airspace within a burrow, from interstitial vapor migration. This exposure pathway is limited to volatile organic compounds. Inorganic compounds do not volatilize. This pathway is generally considered an insignificant route of migration for semivolatiles except in unusual circumstances, such as following an accidental spill or release.

The detection of volatile organics was sporadic, implying emissions would arise from various areas of limited contamination. In addition, the volatile compounds would become rapidly diluted into the atmosphere, further reducing the concentration of the limited emissions. This pathway is not likely to represent a significant migration pathway because the resulting concentrations are likely to be negligible.

Wind erosion may result in airborne particulates containing site-related chemicals resulting in exposure via inhalation. The results of air sampling for particulates have concluded that wind erosion is not a viable current migration pathway for these areas.

A.7.1.3.2 Exposure Pathways

The assessment of ecological exposure pathways includes an examination of the nature of contamination, the media impacted, the identification of potential receptors, and the determination of potential exposure routes for the ecological receptor groups. Pathways will be addressed for the following ecological groups: plants, invertebrates, and wildlife.

Soils

Ecological receptors may come in contact with contaminants in surface soils and near-surface soils. Chemicals present in soils below 5 feet are considered isolated from ecological receptors, because few organisms burrow below this depth. Therefore, chemicals leaching from surface soils and into lower strata are reducing the potential for exposure to ecological receptors. Chemicals present in near-surface soils (0 to 5 feet) are isolated from most ecological receptors except for the larger burrowing animals (e.g., red fox).

Terrestrial plants are exposed to chemicals in soils primarily through uptake via the plants' root systems. Chemicals absorbed by the roots are then transported throughout the plant via the xylem and phloem.

Terrestrial invertebrates are the organisms at greatest potential risk that inhabit the soils (e.g., insect larvae and earthworms). These organisms are primarily exposed via dermal contact and ingestion of soils. Terrestrial invertebrates obtain water and exchange respiratory gases across their epidermis. Therefore, dermal contact includes absorption of chemicals from soil in interstitial water and soil gases.

Terrestrial wildlife organisms may be exposed to chemicals in soil as a result of ingestion and dermal absorption. Soil ingestion may be inadvertent or it may be deliberate. Inadvertent ingestion of soils may occur during feeding, especially consumption of vegetation, burrowing, or grooming and preening activities. Some animals ingest soils as a source of supplemental minerals (e.g., deer) or consume soil to aid in digestion (e.g., birds).

Dermal absorption is considered to be a negligible exposure pathway because the presence of fur or feathers is likely to prevent the soil from coming in direct contact with the skin. However, the soil trapped in the fur or feathers is likely to be ingested during grooming or preening activities. The low rate of dermal absorption relative to absorption via the gastrointestinal tract would also limit the relative uptake of a chemical via the dermal pathway.

Groundwater and Surface Water

Contaminants in groundwater are effectively isolated from ecological receptors. Exposure to contaminants in groundwater may occur if the groundwater discharges to the surface. Identified surface waters which may be impacted by site-related chemicals include puddles, water in the drainage ditches, the north surface water body, and the seep.

With the exception of algae and other similar aquatic plants, exposure of plants to chemicals in surface water is not likely to be significant. The primary uptake pathway in plants is via uptake by the roots (Sample et al. 1997)

Wildlife may receive significant exposures from surface waters including puddles, water in the drainage ditches, and the north surface water body. There is a seep located in the southwest corner of Area 2 immediately above the Ford property, however exposure of ecological populations to these chemicals is expected to be minimal. Water discharges from the seep only following significant rain events, therefore, this seep does not represent a constant source of water. Wildlife are opportunistic and will drink from the nearest water source, including puddles. In the event of a substantial rain event, (i.e., one where there is enough precipitation to saturate soils, resulting in perched water exiting the seep), there would be substantial numbers of puddles present in Area 2 which would provide water for wildlife. The ecological survey noted a number of hydrophilic plant communities, indicating the water tends to pond throughout Area 2. Therefore, exposure to the seep would be sporadic at best, resulting when an organism was near the seep at a time when it was flowing. Given the intermittent nature of potential exposure, potential exposure is likely to be insignificant relative to exposure to contaminants in surface water puddles and small ponds.

Terrestrial wildlife may be exposed to chemicals in surface water as a result of ingestion and dermal absorption. Ingestion of water is considered the major exposure pathway. Exposure via

dermal absorption would be sporadic and the amount of skin area exposed is likely to be limited to the lower limbs of the animal. In addition, uptake of chemicals is highly dependent on lipophilicity, because the stratum corneum (the outer skin layer) is rich in lipid content, and tends to act as a sink, reducing transport of chemical to the systemic circulation, unless a steady state is reached, which requires exposure to take place over an extended period of time (EPA 1992c). Given the limited exposure time involved in an incidental exposure, this equilibrium will not be reached. In addition, uptake across the skin is far less efficient than across the gastrointestinal tract, further reducing the significance of exposure relative to ingestion. Exposure via dermal contact is insignificant when compared to the ingestion pathway; therefore, dermal absorption was not evaluated.

Volatile Organic Vapors

Burrowing organisms may be exposed to contaminants that volatilize into their burrows. As previously discussed, the source term for volatiles are sporadic and limited in areal extent. Therefore, potential exposures are limited because the probability of burrowing within a contaminated area is low. In addition, if an organism burrows within one of these areas, the presence of volatile organics may deter the animal from residing within the contaminated area, given the large area that is not contaminated. Therefore, exposure via this pathway is not considered to be significant and will not be evaluated.

Food Sources

Higher organisms may be exposed to chemicals that have bioconcentrated into food items (e.g., plants, invertebrates, and prey organisms). This pathway will be evaluated; however, there is much uncertainty associated with estimating potential exposure concentrations in prey organisms. A simplified food web for the West Lake Landfill is presented in Figure A.7-1.

In summary, the potential exposure pathways that will be addressed for Areas 1 and 2 include:

- Direct contact with soils for plants and invertebrates,
- Ingestion of soils by wildlife,
- Ingestion of surface water by wildlife, and
- Ingestion of food (i.e., plants and prey organisms) by wildlife.

Potential exposure via these pathways will be addressed in the Exposure Assessment, Section A.7.2.1.

A.7.1.4 Selection of Assessment Endpoints

An assessment endpoint is a formal expression of the environmental values to be protected (Suter 1993). Ecological assessment endpoints to be addressed for Operable Unit 1 include any reduction in the population of a selected species resulting from site-related chemicals. Plants will be evaluated on a community level. However, it should be noted that all of Area 1 and Area 2 (exclusive of the Ford property) are located within the boundaries of an active landfill operation. Therefore, alteration of the plant communities is necessary to meet the needs and requirements of the landfill operation.

The primary measurement endpoints are mortality or reduced reproductivity of individuals. The measurement of these endpoints are the comparison of acceptable concentrations of contaminants in soils which will not have an adverse effect on plants or soil invertebrates. Similarly, estimated doses for mammals and birds will be compared to acceptable doses which are not likely to have a significant impact on the reproductive ability of the organism. In the absence of toxicological data concerning the effects of contaminants on reproduction, other toxicological endpoints will be used (e.g., alterations in liver function or renal toxicity). As a conservative assumption, it is assumed that all toxicological endpoints will affect the ability of the organism to reproduce.

A.7.1.5 Site Conceptual Model

An ERA conceptual model is based on consideration of the ecological community or components potentially at risk, chemical characteristics, and exposure pathways. The exposure scenarios evaluated in the conceptual model consider sources, environmental transport mechanisms, partitioning of the chemicals between various environmental media, potential exposure routes, and the types of ecological receptors that could potentially be exposed.

The conceptual model for the West Lake Landfill is shown in Figure A.7-2.

A.7.2 ECOLOGICAL EXPOSURE ASSESSMENT

The ecological exposure assessment develops the information, collected during the problem formulation, to evaluate and quantify exposure levels. The purpose of this assessment is to evaluate the likelihood and magnitude of exposure of ecological receptors to contaminated media in Areas 1 and 2. The ecological exposure assessment has four elements: (1) characterization of the ecological setting in which the receptors could be exposed, (2) selection of receptor species

for evaluation (receptor species identification), (3) identification of actual or potential exposure pathways and routes for these receptors (ecological exposure pathways), and (4) estimation of the magnitude of chemical exposures for selected receptor species (quantification of exposure). The biological characterization of the West Lake Landfill has been discussed previously in Section A.7.1.1. The remaining three elements of the ecological exposure assessment are discussed below.

A.7.2.1 Selection of Representative Receptor Species

To evaluate quantitatively the magnitude of adverse impacts that may occur at a given site, specific representative wildlife species were selected for each area to develop the quantitative risk evaluation. Receptor species were selected from each trophic level (i.e., plants, herbivores, and predators) represented in terrestrial food webs specific to Operable Unit 1. The criteria used to select receptor species included the following:

- The species occurs or potentially occurs at the West Lake Landfill,
- The species is likely to be exposed to chemicals present at the West Lake Landfill,
- The species is sensitive to chemicals at the West Lake Landfill,
- The species is representative of sensitive or valuable guilds or habitats present at the West Lake Landfill, and
- The species is of particular economic or social value.

In all cases, the selection of receptor species was conducted in a conservative manner. Species most likely to be exposed to contaminated media and species expected to be most sensitive to exposure to chemicals were selected. No species of economic or social value were identified in the wildlife survey, therefore, this criteria is not applicable to this site. A spatial scale was considered when selecting receptor species. Selection of a species with large home ranges is not appropriate for small areas, such as those in Operable Unit 1. A species with a large home range (e.g., 10,000 acres) may spend little time on a small site (e.g., 5 acres); thus its exposure would be much less than an otherwise similar species with a smaller home range. For species with a large home range, risks will be evaluated on an operable unit-wide basis. This will take into account the potential exposure of an organism to chemicals from both areas. It is assumed that impacts on the selected species will be representative of potential impacts on similar species (i.e., species occupying the same ecological niche) that occur or might be present in Operable Unit 1.

The following types of ecological receptors were expected to be present in Operable Unit 1 (representative species or taxa were selected from each): terrestrial plants (trees, shrubs, and

herbs); soil invertebrates (e.g., earthworms); terrestrial mammals (e.g., white-footed mouse, eastern cottontail, and red fox); and terrestrial birds (e.g., American robin, American woodcock, and red-tailed hawk). A general description of the biology of the representative species is given below.

Reptiles are likely to be present on Operable Unit 1. However, the toxicological information required to evaluate the risk to these receptors is not available. Therefore, the potential risk to this group of animals cannot be assessed.

White-Footed Mouse (*Peromyscus leucopus*) Deer mice are omnivorous and highly opportunistic feeders. Their diet consists mainly of arthropods, seeds, fruit, and other vegetation (EPA 1993c). These mice are most abundant in habitats that includes a canopy, such as brushy fields and deciduous woodlots (EPA 1993c). The mean home range of these animals is 0.15 acres (Sample and Suter 1994). The body weights for this mouse range from 14 g to 31 g (EPA 1993c).

Eastern Cottontail (*Sylvilagus floridanus*) The eastern cottontail is the most widely distributed of the medium-sized rabbits. It is found all over the eastern United States and southern Canada and has been widely introduced in the west (EPA 1993c). These animals are strictly herbivores, feeding primarily on herbaceous plants, but they may feed on woody plants in the winter when herbaceous plants are scarce (Chapman et al. 1982). This species of rabbit has a large variety of habitats, including glades and woodlands, deserts, swamps, prairies, hardwood forests, rain forests, and boreal forests. Open grassy areas generally are used for foraging at night, whereas dense, heavy cover typically is used for shelter during the day (EPA 1993c). Home ranges for eastern cottontails tend to overlap and the range size is often dependent on the type and size of habitat available. Measured home ranges vary from 3.7 acres to almost 10 acres (EPA 1993c). The average body weight for the eastern cottontail is 1.18 kg (EPA 1993c).

Red Fox (*Vulpes vulpes*) The red fox, is a mammalian predator and lives within burrows. This animal preys on birds and on burrowing mammals. The red fox also feeds on berries and fruit when available (DeGraaf and Rudis 1986, Martin et al. 1951). Plant material is most common in red fox diets in summer and fall when fruits, berries, and nuts become available (EPA 1993c). The red fox utilizes many types of habitats, but prefers areas with broken and

diverse upland habitats that occur in most agricultural areas (EPA 1993c). The red fox has a home range of approximately 250 acres (DeGraaf and Rudis 1986, Godin 1977, Baker 1983). The body weights for this animal range from 3.9 kg to 5.3 kg (EPA 1993c).

American Robin (*Turdus migratorius*) This ground-gleaning bird feeds on fruits and soil invertebrates. The American robin is a passerine bird and occurs throughout most of the continental United States and Canada during the breeding season. The robin winters in the southern United States, Mexico, and Central America (EPA 1993c). The robin inhabits open woodlands and woodland edges and clearings. Its diet consists of fruit, earthworms, and various insects. Approximately 60% of its diet consists of plant matter; the remainder consists of terrestrial invertebrates, such as caterpillars, beetles, sowbugs, millipedes, and invertebrates (DeGraaf and Rudis 1986, Martin et al. 1951). The home range of the robin can vary from between 0.3 acres to 0.75 acres (DeGraaf and Rudis 1986). The body weights for this bird range from 77 g to 86 g (EPA 1993c).

American Woodcock (*Scolopax minor*) Woodcocks inhabit both woodlands and abandoned fields, particularly those rich in organics, with moderately to poorly drained loamy soils, which tend to support abundant invertebrate populations. Woodcocks feed primarily on invertebrates found in moist upland soils by probing the soil with their long prehensile-tipped bill. Earthworms are the preferred diet, but when earthworms are not available, other soil invertebrates, seeds and other plant matter may also be consumed (EPA 1993c). The home range of woodcocks varies in size depending on season and the distribution of feeding sites and suitable cover. Home ranges have been reported as small as 7.7 acres up to 80 acres (EPA 1993c). The body weights for these birds range from 134 g to 218 g (EPA 1993c).

Red-Tailed Hawk (*Buteo jamaicensis*) This widely distributed hawk, nests primarily in woodlands, and feeds in open country on a wide variety of small- to medium-sized prey. Small prey (e.g., mice, shrews, voles, rabbits and squirrels) are an important source of food, but these hawks will eat a wide variety of prey depending on availability, including birds, lizards, snakes, and large insects (EPA 1993c). The red-tailed hawk is territorial throughout the year. The average home range of these hawks, as measured in an environment similar to that present at the West Lake Landfill, was 1,720 acres (EPA 1993c).

A.7.2.2 Exposure Pathways

Ecological receptors on Operable Unit 1 may be exposed to chemicals in surface soils, near-surface soils and surface water. A summary of potential exposure pathways is given in Table A.7-3. Plants and invertebrates will be exposed to chemicals in surface soils via direct contact. The white-footed mouse, American robin, and American woodcock may be exposed to chemicals in surface soils via direct ingestion and bioconcentration of chemicals into food items.

The eastern cottontail and red fox may be exposed to chemicals in surface soil via ingestion and near-surface soil as a result of burrowing. The rabbit, a herbivore, may be exposed to chemicals in surface soils via bioconcentration into food sources. The red fox may be exposed to chemicals both in the surface soils and near-surface soils as a result of bioconcentration in the food chain. The rabbit may serve as a potential source of exposure to chemicals in near-surface soils as a result of bioconcentration in the tissue of the animal.

The red-tailed hawk is not likely to be exposed to chemicals in soils as a result of direct ingestion. This raptor nests in trees and spends most of its time hunting or perched in trees, limiting its exposure to soils. Although some soils may be trapped in the fur of prey organisms, the total amount of soil ingested is not likely to be significant. The hawk may be exposed to chemicals in surface and near-surface soils as a result of bioconcentration in the food chain.

All terrestrial mammals and birds may be exposed to chemicals in surface waters as a result of direct ingestion. The predators (i.e., the red fox and red-tailed hawk) may be exposed to waterborne chemicals as a result of bioconcentration in the food chain.

A.7.2.3 Quantification of Exposure

The quantification step identifies the combination of exposure variables or parameters that results in the maximum potential exposure that may occur. For the purposes of the screening risk assessment, the maximum detected concentration is used as the exposure concentration in abiotic media (EPA 1997).

The maximum concentration detected in soils collected from 0 feet to 2 feet, was used as the soil exposure concentration for non-burrowing animals. The maximum concentration for samples collected between 0 feet to 5 feet was used for the soil exposure concentration for burrowing

animals. For exposure via bioconcentration in the food chain, it is assumed that the prey organism or food source was exposed to the maximum concentration for all respective environmental media. The estimation of exposure concentrations is discussed below.

A.7.2.3.1 Estimation of Exposure Concentrations

One of the COPCs, uranium, was measured in terms of activity concentration (pCi/g) instead of in terms of mass concentration (mg/kg). The activity of uranium can be converted to mass using the specific activity of uranium-238. Uranium-238 makes up over 99% of the mass of natural uranium. There are 0.336 pCi of uranium-238 activity for every microgram of natural uranium. Therefore, the uranium concentration in mg/kg was calculated by dividing the uranium-238 radionuclide concentration (pCi/g) by the uranium-238 specific activity (0.336 pCi/μg).

The exposure concentrations for the surface water were based on the maximum detected concentrations in runoff water samples and the water samples from the north surface water body for Area 2.

A food-web exposure model was employed to estimate intakes of COPCs for potential receptor species at various trophic levels within the ecological community potentially inhabiting Operable Unit 1. Terrestrial wildlife and avifauna indicator species were selected to evaluate potential ingestion of contaminated food by terrestrial animals. To estimate dietary exposure concentrations for terrestrial wildlife, tissue concentrations of COPCs in prey of the selected receptor species were estimated based on prey-specific bioconcentration factors (BCFs). BCFs in plants and invertebrates were defined as the ratio of the COPC concentrations in plant or invertebrate tissue to the COPC concentrations in surface soils. Avian and mammalian prey item BCFs are defined as the ratio of the COPC concentration in the tissues of these receptors to the concentration in their diets.

The BCFs were obtained from the published literature or derived using an appropriate bioconcentration model. The BCF values obtained from the literature are summarized and presented in Tables A.7-4 through A.7-6. For those chemicals which have a large number of BCF values (N>100), the 90th percentile value was used. This was done because the 90th percentile value is likely to be more representative of the upper BCF value, as opposed to the maximum value, which may be a data outlier. For those chemicals which have less than 100

values, the maximum value was used.

Plants

Uptake of contaminants by plants is often dependent on the concentration in soil. In general, uptake increases with soil concentration until the contaminant becomes toxic to the plant (McBride 1995). Contaminants that are also nutrients may be regulated by plants such that uptake varies little relative to soil concentration. Nutrients and chemicals that mimic nutrients are often taken up by active processes, rather than in transpiration water. The various forms of particular metals (e.g., chromium and mercury) complicates the estimation of uptake. Some investigators have observed that the uptake of monovalent cations follows Michaelis-Menton kinetics (Baker 1983), but general or specific models for uptake of metals by plants are not well developed. Estimation of uptake of metals and other inorganics from soil by plants is generally performed using uptake factors or BCFs (Sample, et al. 1997).

The BCF values for seven metals (arsenic, cadmium, copper, lead, nickel, selenium, and zinc) were obtained from the published literature. The results are summarized in Table A.7-4. The uptake values for the remaining compounds were taken from Baes et al. (1984).

Unlike metals, models for the uptake of organic chemicals by plants are more common, probably because plant physiology plays a greater role in determining uptake of inorganic contaminants. These models range from the simple ranking of potential for uptake, based on the octanol-water partition coefficient (Scheunert et al. 1994) to the transport of water through xylem and phloem of a single or three-leafed plant, as determined by compartment volumes, cell wall thickness, diffusion, and partition coefficients of cell membranes (Boersma et al. 1988, 1991).

The model used in this ERA (Travis and Arms 1988) was selected because it estimates the concentration of contaminant in aboveground foliage, based on uptake from soils. The BCF is estimated as follows:

$$\log BCF_p = 1.588 - 0.578(\log K_{ow})$$

Eq. A.7- 1

where:

BCFp = bioconcentration factor for aboveground vegetation (unitless)
K_{ow} = octanol-water partitioning factor

The concentration in plants is based on dry weight. The concentration is converted to a wet weight by multiplying the BCF by 0.2 [one minus the average water content of plants (80% by weight)] (Sample and Suter 1994). The BCFs for plants are given in Table A.7-4.

Invertebrates

Uptake of chemicals in soil invertebrates has been better characterized in earthworms than in other invertebrates. Although there is some information available on the kinetics of invertebrate uptake (Belford et al. 1994), all available operational models are based on equilibrium partitioning with soil. The BCF values for metals was taken from the published literature and are summarized in Table A.7-5.

There are several models for estimating the BCFs for organic contaminants for invertebrates. These models are based on the partitioning of organics between the soil and the earthworm lipids. The models take into consideration various factors including the proportion of lipid in earthworms, the fraction of organic carbon in soils, and the octanol-water partitioning coefficient. The following model was selected because it takes into consideration the variations in the affinity of chemicals for lipids (Connel 1990):

$$BCFw = 0.44(K_{ow})^{0.05}$$

Eq. A.7- 2

where:

BCF_w = bioconcentration factor for invertebrate (kg soil/kg worm)
K_{ow} = octanol-water partitioning factor

The model does not address retardation resulting by large concentrations of organic carbon which may be present in some soils or the differences in bioaccumulation resulting from variations in the lipid content of the earthworms. However, data on the lipid content of earthworms at this site were not available. The BCFs for invertebrates are given in Table A.7-5.

Wildlife

The mammalian BCFs for inorganic compounds were obtained from the published literature and are summarized in Table A.7-6. For the purposes of this risk assessment, the maximum value was used. In the absence of data for inorganic chemicals, the BCFs for the bioconcentration of inorganics in beef cattle were used (Baes et al. 1984). BCF values are given in Table A.7-6.

BCF values for uptake of inorganic compounds by birds were not found in the available literature. Therefore, the BCFs for mammals were used as surrogate values.

Garten and Trabalka (1983) developed models for estimating bioconcentration of organic compounds in the fat of animals. The following are the equations for uptake into the fat of nonruminant animals and birds, respectively:

$$\log BCF_m = -3.849 + 0.617 (\log K_{ow})$$

Eq. A.7- 3

and,

$$\log BCF_B = -2.743 + 0.542 (\log K_{ow})$$

Eq. A.7- 4

where:

BCF_m = bioconcentration factor for fat in nonruminant mammals (mg/kg of fat/mg/kg of diet)

BCF_b = bioconcentration factor for fat in birds (mg/kg of fat/mg/kg of diet)

The fat content of mammal tissue and bird tissue typically ranges between 4% to 35% (Hope 1995). As a conservative assumption, it was assumed that all mammal and bird tissue contained 50% fat. Therefore, the BCF is multiplied by 0.5. The BCF values are listed in Table A.7-6.

A.7.2.3.2 Life History Parameters

The life history parameters for the selected species were obtained from *Estimating Exposure of Terrestrial Wildlife to Contaminants* (Sample and Suter 1994), with exceptions as noted below. A discussion of the life history parameters for each target species is given below and summarized in Table A.7-7.

White-Footed Mouse Diet compositions from three different studies give values ranging from 75% arthropods and 34% vegetation to 30% arthropods and 67% vegetation (Sample and Suter 1994). The average values from the three studies were used. It was assumed that 2% of the diet consisted of soil, and 2% of the diet is unknown. For the purposes of this risk assessment, the 2% unknown is assumed to consist of equal portions of invertebrates and vegetation.

Eastern Cottontail. For the purposes of this ERA a home range of 3.7 acres was used, which is the lowest value given in the EPA *Wildlife Exposure Factors Handbook* (EPA 1993c).

Red Fox The diet composition for the fox included 5.5% miscellaneous material (Sample and Suter 1994). This value was assumed to be equally composed of small mammals, birds, plants, and insects. Each of these taxa was previously estimated for the fox's diet.

American Robin A study by Wheelwright (1986) gives the percent (by volume) of the consumption rate of fruits and invertebrates during the four different seasons. The values were averaged and it was assumed that invertebrates and vegetation had the same density (i.e., the percent by volume was equal to the percent by weight).

American Woodcock The document lists three different home ranges, based on different activities: singing, active, and inactive. It is assumed that the bird would not be inactive the entire year. Therefore, the range for the singing bird was used (26 acres) which is smaller than for the active bird (180 acres).

Red-Tailed Hawk This hawk will eat a wide variety of foods depending on their availability (EPA 1993c). The values used in this risk assessment are: 78.5% small mammals, 8.5% birds and 13.0% snakes (Janes 1984 [as reported in Sample and Suter 1994]). It was assumed that snakes were not present and that the hawk's diet was supplemented by equal portions of small mammals and birds. Therefore, the values used in this ERA are 85% small mammals and 15% birds.

A.7.2.3.3 Quantification of Exposure of Wildlife Species

Exposure of an animal comes from multiple sources. They consume contaminated food, drink contaminated water, and ingest contaminated soil. The total oral exposure of an animal is the sum of the exposures attributable to each source and may be described as :

$$E_{total} = E_{water} + E_{soil} + E_{food}$$

Eq. A.7- 5

where:

E_{total} = total exposure from all pathways
E_{water} = exposure from water consumption
E_{soil} = exposure from soil consumption
E_{food} = exposure from food consumption

The exposure from each pathway is estimated using the following equation:

$$E_i = \sum_{j=1}^{m} \left(\frac{IR_j \bullet C_{ij}}{BW} \right)$$

Eq. A.7- 6

where:

E_i = total exposure to chemical (i) (mg/kg/d)
m = total number of ingested media (e.g., food, water, or soil)
IR_j = consumption rate for medium (j) (kg/d or L/d)
C_{ij} = concentration chemical (i) in medium (j) (mg/kg or mg/L)
BW = body weight of endpoint species (kg)

An animal may ingest more than one type of food or prey item. Each of these different food types may have different chemical concentrations. Therefore, the potential exposure from all of the different food types must be summed:

$$FE_i = \sum_{j=1}^{m} \left(\frac{FIR_j \bullet C_{ij}}{BW} \right)$$

Eq. A.7- 7

where:

C_{ij} = concentration of chemical (i) in food type (j) (mg/kg, fresh weight)
FE_i = exposure to chemical (i) attributed to food (mg/kg/d)
FIR_j = ingestion rate (kg/individual/day) for the j^{th} food type

The ingestion rate for each food type, FIR_j, may be estimated as follows:

$$FIR_j = P_j \bullet FIR$$

Eq. A.7- 8

where:

P_j = proportion of the j^{th} food type in the diet and
FIR = total food ingestion rate (kg/individual/day)

The red fox and the red-tailed hawk may be exposed via bioconcentration of chemicals in small mammals and birds. Both of these species feed on rodents and rabbits (EPA 1993c). For the purpose of estimating intake via consumption of small mammals, it was assumed that their diet of small mammals consisted of equal amounts (by weight) of small rodents and rabbits. Exposure from small rodents is represented by the white-footed mouse. Exposure via birds was assumed to come solely from the robin. This bird was selected because its diet consists of almost equal portions of invertebrates and vegetation. Therefore, it would be representative of exposures for chemicals bioconcentrated from both invertebrates and vegetation. To include other species which feed predominantly on either invertebrates or vegetation, would skew the exposure values toward chemicals that bioconcentrated in either the invertebrates or vegetation.

Larger animals and birds may have a home range that is greater than the area of Operable Unit 1. Therefore, not all of the food, soil, and water the organism ingests, is likely to be contaminated. The proportional contribution of contaminated food and environmental media are addressed by using the following formula:

$$E_i = \frac{A}{HR}\left[\sum_{j=1}^{m}\left(\frac{IR_j \times C_{ij}}{BW}\right)\right]$$

Eq. A.7- 9

where:

A = area (acres) contaminated, and
HR = home range size (acres) of endpoint species

Wide-ranging animals are likely to be exposed to chemicals in both areas. Exposure of these organisms to chemicals at multiple areas is estimated as follows:

$$E_i = \sum_{k=1}^{o}\left\{\frac{A_k}{HR}\left[\sum_{j=1}^{m}\left(\frac{IR_j \times C_{ijk}}{BW}\right)\right]\right\}$$

where:

o = number of waste areas
A_k = area (acres) of the k^{th} waste area (acres)
C_{ijk} = concentration of chemical (i) in the j^{th} medium type, in the k^{th} waste area (mg/kg or mg/L)

The red fox may be exposed via ingestion of soil, surface water, and prey. The majority of soil exposure is likely to occur as a result of denning (i.e., inadvertent soil ingestion resulting from burrowing or ingesting soil from the den during grooming). Therefore, direct exposure to chemicals in soils is likely to occur predominantly within a specific area as compared to exposure to chemicals throughout the range of the animal. Inversely, the red fox is likely to obtain prey items and water throughout its range. Therefore, in estimating the potential exposure to the red fox, the home range factor is not applied to the ingestion of soils, but it is applied to the ingestion of prey and surface water.

$$E_{fox} = \frac{IR_s \bullet C_s}{BW} + \left\{ \frac{A_1}{HR} \left[\sum_{i=1}^{n=1} \left(\frac{FIR_i \bullet C_i}{BW} \right) + \frac{IR_w \bullet C_w}{BW} \right] \right\} + \left\{ \frac{A_2}{HR} \left[\sum_{i=1}^{n=2} \left(\frac{FIR_i \bullet C_i}{BW} \right) + \frac{IR_w \bullet C_w}{BW} \right] \right\}$$

Eq. A.7- 10

where:

E_{fox} = Exposure for the fox (mg/kg/day)

IR_s = Ingestion rate of soil (kg/day)

C_s = Chemical concentration in soil (mg/kg)

BW = Body weight (kg)

A_1 = Area of Area 1 (acres)

HR = Home range of the fox (acres)

n = The area, i.e., Area 1 or 2

I = The type of food source

FIR_i = Ingestion rate for the i^{th} food type (kg/day)

C_i = Chemical concentration in the i^{th} food type (mg/kg)

IR_w = Ingestion rate of surface water (L/day)

C_w = Chemical concentration in surface water (mg/L)

A_2 = Area of Area 2 (acres)

The exposure concentrations in abiotic media and the estimated concentrations in biota for Areas 1 and 2 are given in Tables A.7-8 and A.7-9, respectively. The estimated intakes for contaminants in Area 1 by the white-footed mouse, cottontail rabbit, and American robin are given in Tables A.7-10, A.7-11, and A.7-12, respectively. The estimated intakes for contaminants in Area 2 by the white-footed mouse, cottontail rabbit, and American robin are given in Tables A.7-13, A.7-14, and A.7-15, respectively. The intakes for the red fox, which has a home range which is larger than the combined areas of the two sites, is given in Table A.7-16. Similarly, the American woodcock and red-tailed hawk also have large home ranges. The intakes for these birds are given in Tables A.7-17 and A.7-18, respectively.

A.7.3 ECOLOGICAL EFFECTS ASSESSMENT

Toxicological effects associated with ecological exposure to COPCs and the effect threshold concentrations (or benchmarks) for the endpoints being evaluated are described in this section.

The primary ecological endpoints are mortality or reduced reproductivity of individuals in a population. The benchmark values represent doses which would not have an adverse affect upon the reproductivity of the organism. Reproductive toxicity studies are not always available. In the absence of such data, other adverse affects, such as histological changes in organ systems, clinical signs of toxicity, etc., were used to derive the benchmark values. These values are often conservative because some changes in histology or physiology of an organism does not affect its ability to survive and reproduce. Benchmark values for ecological receptors were obtained from *Screening Benchmarks for Ecological Risk Assessment (Version 6.1)* (ORNL 1996), or they were derived based on the toxicological data from the published literature. A discussion of the derivation of benchmarks for each taxonomic group is given in the following sections. The benchmark values are summarized in Table A.7-19.

A.7.3.1 Derivation of Benchmark Values For Plants

Toxicity data for use in deriving benchmark values for plants could not be found in the literature. Surrogate values for some chemicals were identified from the available benchmark values.

Di-n-ocylphthalate Di-n-butylphthalate was the only phthalate with a benchmark value, 200 mg/kg (ORNL 1996). This benchmark value was also used for di-n-octylphthalate, because of the similar chemical structure. The di-n-octylphthalate has two 8-carbon chains as compared to two 4-carbon chains for di-n-butylphthalate. Di-n-octylphthalate is less soluble in water than di-n-butylphthalate, therefore, it will not be taken up by the plant as readily, reducing the potential exposure "dose". Therefore the use of this benchmark value is a conservative assumption.

A.7.3.2 Derivation of Benchmark Values for Earthworms

The literature search for toxicological data for use in deriving benchmark values were limited to those studies in which invertebrates were exposed to soil (natural or artificial mixtures), soil/litter microcosms, or manure were considered for evaluation. The main alternative method is the contact filter paper test in which the organisms are placed on filter paper containing the test chemical. Results are reported as mg chemical per cm^2 filter paper. These results are not directly comparable to soil concentrations (mg chemical/kg soil). In addition, this type of toxicity test fails to address toxicity via the oral pathway. Heimbach (1988) reports that there is little correlation between contact paper test and artificial soil test results. However, there is good correlation between artificial soil tests and field test results for several pesticides (Heimbach 1992).

The toxicity data used for the derivation of benchmark values for invertebrates are given in Table A.7-20. An uncertainty factor of 5 was used to derive benchmark values from LC_{50} data. LC_{50} is that concentration of contaminant that is lethal to 50 percent of the exposed population within the specified time period. This was the same protocol used by Will and Suter (1994b) in the derivation of benchmark values for other chemicals.

Polycyclic Aromatic Hydrocarbons (PAHs) Fluorene was the only PAH which had a benchmark value available, 30 mg/kg (ORNL 1996). This value was used as the benchmark value for the other PAH. In contact toxicity studies fluorene was more toxic than naphthalene or fluoranthene; however, it was less toxic than acenapthalene (Neuhauser et al. 1985). Although fluorene was not the most toxic PAH tested, it is more toxic than the two other PAHs which are COPCs. Therefore, the actual toxicity of the PAHs is likely to be less than this compound.

Phthalates The benchmark value for dimethylphthalate was used for all of the phthalates. In contact toxicity studies dimethylphthalate was more toxic than diethylphthalate, n-butylphthalate, dioctylphthalate, or bis(2-ethylhexyl) phthalate (Neuhauser et al. 1985). Therefore, this is a conservative value for evaluating potential risks associated with exposure to phthalates.

Dieldrin The benchmark value for dieldrin is 30 mg/kg. This is based on a study by Reinecke and Venter (Reinecke and Venter 1985), in which invertebrates (*Eisenia fetida*) were exposed to various concentrations of dieldrin in cow manure for 90 days to determine potential affects on growth and reproduction. The no-observable effect concentration (NOEC) for reproduction was 30 mg/kg.

Aldrin The benchmark value for aldrin is 2.2 mg/kg. The 14-d LC_{50} for the invertebrate, *Pheretima posthuma*, is 10.79 mg/kg, based on a toxicity test using soil pots (Hans et al. 1990). An uncertainty factor of 5 was applied to derive the final benchmark value.

Endosulfan The benchmark value for endosulfan is 1.0 mg/kg. The 24-hr LC_{50} for the invertebrate, *Pheretima posthuma*, is 5.01 mg/kg, based on a toxicity test using soil pots (Hans et al. 1990). An uncertainty factor of 5 was applied to derive the final benchmark value.

DDT, DDD, and DDE The benchmark value for DDT is 2,000 mg/kg. This value is based on a NOEC for an undefined toxicity endpoint using soil pots (Edwards and Thompson 1973). This benchmark value will also be used for DDD and DDE.

A.7.3.3 Derivation of Benchmark Values for Birds

A literature search was conducted for toxicological values for those COPCs that were not listed in the database. Because of the differences in avian and mammalian physiology, only toxicity data for birds were taken into consideration. No additional data could be found in the available literature.

A.7.3.4 Derivation of Benchmark Values for Mammals

In selecting toxicity data for deriving benchmark values for mammals, consideration was given to selecting toxicity data from experiments that would most closely model exposure of the organisms in the field. Chronic toxicity studies were selected that evaluated significant endpoints that could be used to evaluate the long-term effects on natural populations. Data from studies involving exposure via food or water were used instead of gavage studies, given that these types of exposures would most closely model the exposure of wildlife. Studies which evaluated endpoints such as reproductive and developmental toxicity, and reduced survival were used whenever possible; however, these data were not available for the chemicals evaluated. Therefore, the available data necessitated the use of endpoints such as organ-specific toxic effects. Data from laboratory species that were either taxonomically or physically similar to the target wildlife species were used.

The no observable adverse effect level (NOAEL) was used for deriving the benchmark values for the target wildlife species. If no NOAEL values were available, the lowest observable adverse effect level (LOAEL) was used. The toxicological data were screened to determine if the NOAEL for one study exceeded the LOAEL for any other studies. This may occur as a result of using different toxicological endpoints or differences in the sensitivity of different types of laboratory animals.

A.7.3.4.1 Estimation of Wildlife Benchmarks from Toxicity Data for Laboratory Animals

The NOAELs and LOAELs are daily dose levels normalized to the body weight of the test animals (e.g., milligrams of chemical per kilogram of body weight per day). The presentation of toxicity data on a mg/kg/day basis allows comparisons across test species with appropriate

consideration for differences in body size. Studies have shown that numerous physiological functions such as metabolic rates, as well as responses to toxic chemicals are a function of body size. Smaller animals have higher metabolic rates and are usually more resistant to toxic chemicals because of more rapid rates of detoxification. It has been shown that the best measure of differences in body size is one based on body surface area which, for lack of direct measurements, can be expressed in terms of body weight raised to the 2/3 power (EPA 1980). If the dose is given in terms of body weight (e.g., mg/kg), then the dose per unit body surface area equates to:

$$D = \frac{d \bullet bw}{bw^{2/3}} = d \bullet bw^{1/3}$$

Eq. A.7- 11

where:

D = dose per unit body surface area
d = dose per unit body weight
bw = body weight

Therefore, the relationship of the toxic dose for two different species can be described as follows:

$$d_a \bullet bw_a^{1/3} = d_b \bullet bw_b^{1/3}$$

Eq. A.7- 12

where:

d_a = dose per unit body weight for species a
bw_a = body weight for species a
d_b = dose per unit body weight for species b
bw_a = body weight for species b

The NOAEL for a wildlife species can be derived from data for laboratory animals using the following equation:

$$d_w = d_l \times \frac{bw_l^{1/3}}{bw_w^{1/3}} = d_l \times \left(\frac{bw_l}{bw_w}\right)^{1/3}$$

Eq. A.7- 13

where:

d_w = dose per unit body weight for wildlife species
bw_w = body weight for wildlife species
d_l = dose per unit body weight for laboratory species
bw_l = body weight for laboratory species

Uncertainty factors were used to address the differences between the LOAEL value and the NOAEL, or when subchronic toxicity data were used instead of chronic toxicity values. In the EPA methodology (EPA 1997d), the LOAEL can be reduced by a factor of up to 10 to derive the NOAEL. As a conservative measure, LOAEL values were divided by 10 to derive the NOAEL. This is a conservative assumption given that the NOAEL may be only slightly lower than the experimental LOAEL, particularly if the observed effect is of low severity. Similarly, an uncertainty factor of 10 was used to convert subchronic values to chronic values.

If the only available data consist of a NOAEL for subchronic exposure, then a UF of 10 was applied. If a subchronic LOAEL was used then a UF of 100 was used (i.e., UF of 10 for using a LOAEL and a UF of 10 for using subchronic data).

EPA has no clear guidance on what differentiates a subchronic exposure from a chronic exposure. For studies on laboratory rodents, EPA generally accepts a 90-day exposure duration as a standard for subchronic exposure. In the guidance for the proposed Great Lakes Water Quality Criteria, EPA (1993c) indicates that a chronic exposure would be equivalent to a least 50% of a species life span. Given that a laboratory rodent generally has a life span of 2 years, 12 months or greater was used as the criterion for determining chronic studies.

Some of the daily doses were administered five days per week. Therefore the reported toxicological value was converted to a daily dose by multiplying the applied daily dose by 0.71 (5 days/7 days). The derivation of benchmark values are summarized in Table A.7-21 and discussed below.

A.7.3.4.1.1 Wildlife Benchmarks

Polycyclic Aromatic Hydrocarbons The only benchmark value for a PAH was benzo(a)pyrene. This value was used as a benchmark for the other PAHs given that this chemical has the greatest toxicity among the PAHs.

Butyl benzyl phthalate In a subchronic toxicity test, it was determined that a daily dose of 1,417 mg/kg/day, via food, had significant effects upon the reproductive system of male rats. The toxic effects included decreased testes size and weight, smaller prostates and seminal vesicle, and testicular lesions, including atrophy of seminiferous tubules an aspermia (EPA 2000). Other toxic effects observed at this concentration included decreased weights for the heart, kidney, and lungs. At a dose of 470 mg/kg/day, the only toxic effect noted is increased liver weight (EPA 2000). A subchronic reproductive NOAEL of 1,417 mg/kg/day will be used to derive the wildlife benchmarks. The increased liver weight observed at the lower dose is not considered to be that serious of a toxicological effect and is likely to have a minimal effect upon the animal's ability to reproduce.

Chlorobenzene. The lowest chronic NOAEL found in the literature for chlorobenzene was 60 mg/kg/day via gavage (5 days per week), based on a study using rats (ATSDR 1990). The LOAEL was 125 mg/kg/day, which resulted in increased liver weight. These same values were reported in a subchronic study using mice and rats. The toxicological endpoint for this study was increased liver weight (ATSDR 1990). A subchronic study using beagle dogs, reported a NOAEL of 27.25 mg/kg/day and a LOAEL of 54.5 mg/kg/day, based on a 5 day/week dosing regime. Histological changes in the liver were noted at 54.5 mg/kg/day. At the next highest concentration (272.5 mg/kg/day), death, body weight loss, changes in hematology, clinical chemistry, and urine analysis, and pathologic changes in the liver, kidney, gastrointestinal mucosa, and hematopoietic tissue were observed. The results from other subchronic rodent studies had LOAELs greater than 60 mg/kg/day, the NOAEL previously reported (ATSDR 1990).

The NOAEL value of 42.9 mg/kg/day (converting the 5 day/week dosage to a daily dosage) was used to derive the benchmark value for the white-footed mouse. This value is greater than the LOAEL for dogs, however, the rodent data are more representative of the toxicity of this chemical to a field mouse.

The NOAEL for the dog study (19 mg/kg/day) will be used to derive the benchmark values for the rabbit and the fox. This value was used because it was the highest NOAEL value which did not exceed the LOAEL from another study.

1,2-Dichlorobenzene In a chronic toxicity study (5 days/wk x 2 years), rats and mice were administered 0, 60 or 120 mg/kg/day. No significant toxicological effects were noted in this study, therefore a converted NOAEL of 85.7 mg/kg/day can be established for both mice and rats (EPA 2000).

For the purposes of estimating a benchmark value for the white-footed mouse, the NOAEL for the mouse will be used. Given that the rat has a weight which is closer to that of a rabbit and fox, the NOAEL for the rat will be used to estimate the benchmark for these animals.

1,4-Dichlorobenzene In the chronic toxicity study (5 days/wk x 2 years), rats were administered 150, 300 and 600 mg/kg/day and mice were administered 150 and 300 mg/kg/day. At 300 mg/kg/day, mice showed lymphoid hyperplasia of lymph nodes, hepatocellular degeneration, nephropathy and renal tubular degeneration (ATSDR 1993). The rats showed moderate nephropathy in males at a chronic dose of 150 mg/kg/day (ATSDR 1993).

For the purposes of estimating a benchmark value for wildlife, the LOAEL for mice (214 mg/kg/day) will be used to estimate the benchmark value for the white-footed mouse. The LOAEL for rats (107 mg/kg/day) will be used to estimate the benchmark values for the cottontail rabbit and the red fox.

2,4-Dimethylphenol Mice were dosed for 90 days, via gavage, with 5.0, 50.0, or 250 mg/kg/day. The animals dosed with 250 mg/kg/day showed clinical signs of toxicity included squinting, lethargy, prostration, and ataxia. The animals in this higher exposure group had statistically significant hematological changes including lower mean corpuscular volume and mean corpuscular hemoglobin concentration in females (EPA 2000). A NOAEL of 50.0 mg/kg/day was used to estimate benchmark values for wildlife.

Ethylbenzene Rats were orally dosed for 182 days (5 days/week) with 13.6, 136, 408, or 680

mg/kg/day. Animals receiving does of 408 and 680 mg/kg/day had histological changes in the liver and kidney (EPA 2000). A subchronic NOAEL of 97.1 mg/kg/day was used to derive the wildlife benchmark values for this chemical.

A.7.4 ECOLOGICAL RISK CHARACTERIZATION

This section characterizes risks to terrestrial receptors potentially exposed to COPCs in Operable Unit 1. The comparison of exposure information with the appropriate concentration-response toxicity data, or estimated absorbed radiation dose, is the basis for the risk characterization. The characterization of chemical and radiological risks will be addressed separately. Potential risks associated with exposure to chemical contaminants will be addressed below in Section A.7.4.1. The radiological risks will be addressed in Section A.7.4.2.

A.7.4.1 Characterization of Chemical Risks

The magnitude of risks depends on the nature, duration, and frequency of exposure to the chemicals and on the characteristics of the exposed populations. This exposure information and the appropriate dose-response toxicity data form the basis of the risk characterization. Risks associated with maximum chronic exposure were evaluated by comparing benchmark concentrations with estimated exposure doses. A hazard quotient (HQ) was calculated for each chemical by dividing the dose generated by the exposure assessment by the benchmark dose obtained from the effects assessment. The HQs of all chemicals are then summed for each receptor organism to obtain the hazard index (HI) for that organism.

The HQ is only a numerical indication that the maximum exposure of an organism has exceeded a dose which will not have an adverse affect upon the organism. Similarly, the HI that is used to evaluate potential risks associated with exposure to numerous chemicals, also provides a numerical indication that the cumulative dose from numerous chemicals does not exceed an acceptable level, based on the assumption that the toxicity of each chemical is additive. An HQ exceeding 1.0 does not in itself imply a hazard. It does indicate that a possible risk to ecological receptors does exist. Further studies would be required to determine if a potential risk does exist and the magnitude of that potential risk.

The mobility of receptor species and the size of their home ranges vary. This difference in mobility has a direct impact on an individual organism's potential to contact contaminated

material from more than one area. Potential ecological risks to less mobile species like plants, invertebrates, white-footed mice, American robin, cottontail rabbit, and animals with small home ranges are assessed for Area 1 and Area 2 separately. Risks to wide ranging receptors like the American woodcock, the red-tailed hawk, and the red fox are addressed by assessing the combined risk from both Area 1 and Area 2.

A.7.4.1.1 Chemical Risk Characterization for Ecological Receptors in Area 1

The HI for plants is 547 (Table A.7-22). With the exception of mercury and beryllium, all of the detected metals in surface soils had HQs greater than 1.0. The primary risk drivers are selenium (HQ=250) and nickel (HQ=120). Conservative assumptions were used in estimating the HQs. The actual HQs are likely to be significantly less (Section A.7.5.2).

The HI for invertebrates is 152 (Table A.7-22). The risk drivers included arsenic, chromium, copper, mercury, nickel and selenium. The primary risk drivers are chromium (HQ = 78), copper (HQ = 46), and nickel (HQ =18). Conservative assumptions were used in estimating the HQs. The actual HQs are likely to be significantly less (Section A.7.5.2).

The HI for the white-footed mouse is 3,320 (Table A.7-23). Metals are the only contaminants to have HQs greater than 1.0. Selenium is the primary risk driver (HQ = 2,590), followed by arsenic (HQ = 515) and copper (HQ = 128). The primary route of exposure was via bioconcentration into food, especially plants. Plants accounted for approximately 97% and 80% of the exposure for selenium and copper, respectively. Food accounted for over 99% of the exposure to arsenic, with approximately equal amounts of exposure from invertebrates and plants. The use of the maximum exposure concentrations resulted in an overestimation of potential risks. The actual HI is likely to be over two orders of magnitude less than the estimated value given here (Section A.7.5.2).

The HI for the cottontail rabbit is 5,750 (Table A.7-23). Metals are the only contaminants to have HQs greater than 1.0. Selenium is the primary risk driver (HQ = 4,880), followed by arsenic (HQ = 610) and copper (HQ = 202). The primary route of exposure was via bioconcentration into plants. Exposure via consumption of plants accounted over 99% of exposure for selenium and copper and accounted for over 95% of exposure to arsenic. The use of the maximum exposure concentrations resulted in an overestimation of potential risks. The

actual HI is likely to be over an order of magnitude less than the estimated value given here (Section A.7.5.2).

The HI for the American robin is 16,000 (Table A.7-23). The primary risk drivers are selenium (HQ = 15,900), copper (HQ = 60), and cadmium (HQ = 49). Arsenic, chromium, lead and nickel also had HQs that exceeded 1.0. Exposure via bioconcentration into food was the primary exposure pathway, with exposure via food accounting for over 99% of the exposure for the selenium and cadmium. The use of the maximum exposure concentrations resulted in an overestimation of potential risks. The actual HI is likely to be over two orders of magnitude less than the estimated value given here (Section A.7.5.2).

Metals are the primary chemical risk drivers for ecological receptors within Area 1.

A.7.4.1.2 Chemical Risk Characterization for Ecological Receptors in Area 2

The HI for plants is 347 (Table A.7-24). With the exception of mercury and beryllium, all of the detected metals in surface soils had HQs greater than 1.0. The primary risk drivers are uranium (HQ=175), chromium (HQ=49), and lead (HQ=44).

The HI for invertebrates is 144 (Table A.7-24). The primary risk driver is chromium (HQ = 123). This is followed by copper (HQ = 7.2). Lead, mercury, nickel and zinc also had HQs greater than 1.0.

The HI for the white-footed mouse is 647 (Table A.7-25). Metals are the only contaminants to have HQs greater than 1.0. Selenium is the primary risk driver (HQ = 394), followed by lead (HQ = 97) and arsenic (HQ = 82). The primary route of exposure was via bioconcentration into food, especially plants, which accounted for over 98% of the exposure to these chemicals. The use of the maximum exposure concentrations resulted in an overestimation of potential risks. The actual HI is likely to be significantly less than the estimated value given here (Section A.7.5.2).

The HI for the cottontail rabbit is 1,700 (Table A.7-25). Metals are the only contaminants to have HQs greater than 1.0. Selenium is the primary risk driver (HQ = 1,350), followed by arsenic (HQ = 176). The primary route of exposure was via bioconcentration in plants.

Exposure via consumption of plants accounted over 99% of exposure for selenium and accounted for over 95% of exposure to arsenic. The use of the maximum exposure concentrations resulted in an overestimation of potential risks. The actual HI is likely to be significantly less than the estimated value given here (Section A.7.5.2).

The HI for the American robin is 15,300 (Table A.7-25). The primary risk drivers are selenium (HQ = 13,700), lead (HQ = 1,240), cadmium (HQ = 220), and chromium (HQ = 107). Exposure via bioconcentration in food was the primary exposure pathway, with exposure via food accounting for over 99% of the exposure for the selenium, lead, and cadmium. The use of the maximum exposure concentrations resulted in an overestimation of potential risks. The actual HI is likely to be significantly less than the estimated value given here (Section A.7.5.2).

Metals are the primary chemical risk drivers for all ecological receptors within Area 2.

A.7.4.1.3 Chemical Risk Characterization for Ecological Receptors Throughout OU 1

The red fox, American woodcock, and red-tailed hawk have large home ranges greater than the area of Operable Unit 1. Therefore, a single organism has the potential to be exposed to contaminants in both areas.

The red fox has an HI of 154 (Table A.7-26). The primary risk driver is cadmium (HQ = 70), followed by selenium (HQ = 47) and arsenic (HQ = 22). Copper, lead and zinc also had HQs greater 1.0. Exposure via food accounted for over 70% of the exposure from cadmium, selenium and arsenic. The use of maximum exposure concentrations, in conjunction with conservative bioaccumulation factors, resulted in an overestimation of potential risks. The actual HI is likely to be significantly less than the estimated value given here (Section A.7.5.2).

The American woodcock has an HI of 442 (Table A.7-26). The primary risk drivers are lead (HQ = 280), and selenium (HQ = 77). Metals were the only other contaminants to have HQs greater than 1.0. Exposure via uptake into invertebrates accounted for approximately 98% of the lead exposure, and approximately 79% of the selenium exposure. The use of maximum exposure concentrations, in conjunction with conservative bioaccumulation factors, resulted in an overestimation of potential risks. The actual HI is likely to be significantly less than the estimated value given here (Section A.7.5.2).

The red-tailed hawk has an HI of 12.2 (Table A.7-26). The primary risk driver is selenium (HQ = 11.9). The remaining chemicals have HQs less than 1.0, with the highest being 0.8 for zinc. Exposure via bioconcentration into food accounts for over 99% of the exposure for this hawk. Exposure to selenium in prey increases with increasing proportion of plants in the prey's diet. The use of maximum exposure concentrations, in conjunction with conservative bioaccumulation factors, resulted in an overestimation of potential risks. The actual HI is likely to be significantly less than the estimated value given here (Section A.7.5.2).

A.7.4.2 Radiological Risks to Ecological Receptors

A screening assessment of radiological risks to ecological receptors was performed using the calculational methodology presented by Sample et al. (1997). The method provides for calculation of external and internal doses to plants and animals. It also provides dose limits of 1000 mrad/d for plants, and invertebrates, and 100 mrad/d for vertebrates (Sample et al. 1997).

The equation used to estimate daily subterranean dose rates from external gamma radiation (radiation originating outside an organism while that organism is underground) is:

$$\text{Dose Rate}_{\text{External Below Ground}} = 1.05 \cdot F_{\text{Below}} \cdot \sum C_{\text{soil},i} \cdot E_i \cdot CF_a$$

Eq. A.7- 14

where:

$\text{Dose Rate}_{\text{External Below Ground}}$ = dose rate to an organism spending 1 day below ground (mrad/d)
$C_{\text{soil},i}$ = concentration of nuclide "i" in soil (pCi/g)
F_{below} = fraction of time spend below ground during 1 day (set to 1)
E_i = average energy of decay for nuclide "i" (MeV/nt)
CF_a = 5.12×10^{-2} (MeV-pCi-d / nt-g-mrad)

The equation used to estimate daily above ground dose rates from external gamma radiation (radiation originating outside an organism while that organism is above ground) is

$$\text{Dose Rate}_{\text{External Above Ground}} = F_{\text{Above}} \cdot F_{ruf} \cdot \sum C_{\text{soil},i} \cdot DF_i \cdot CF_b \cdot ECF$$

Eq. A.7- 15

where:

$DoseRate_{External\ Above\ Ground}$ = dose rate to an organism spending 1 day above ground (mrad/d)

F_{below} = fraction of time spend above ground during 1 day (set to 1)

F_{ruf} = terrain dose rate reduction factor (set to 0.7)

DF_i = dose coefficient for nuclide "i" ($Sv\text{-}m^3/Bq\text{-}s$)

CF_b = 5.12×10^{14} ($mrad\text{-}g\text{-}s\text{-}Bq/Sv\text{-}m^3\text{-}d\text{-}pCi$)

ECF = elevation conversion factor (set to 2 for small mammals)

The equation used to estimate dose rates from internal radiation exposures (radiation originating inside an organism) incurred from breathing contaminated dust is:

$$\text{Dose Rate}_{Internal} = QF \cdot F_{Exposed} \cdot \sum C_{soil,i} \cdot \frac{A}{AD} \cdot E_i \cdot CF_a \cdot AF \quad \text{Eq. A.7-16}$$

where:

$\text{Dose Rate}_{Internal}$ = internal dose rate to an organism exposed for 1 day (mrad/d)

QF = quality factor set to 20 for alpha radiation or 1 for beta or gamma radiation

$F_{Exposed}$ = fraction of time exposed (set to 1)

AF = absorption factor (set to 1, assumes all energy absorbed)

The radionuclides of potential concern in Operable Unit 1 are uranium-238, uranium-234, thorium-230, radium-226, thorium-232, uranium-235, protactium-231, and their associated short-lived daughters. The majority of the gamma radiation at the site is associated with radium-226 and its five prompt daughters: radon-222, polonium-218, lead-214, bismuth-214, and polonium-214. The dose rates from soil containing 1 pCi/g of each of these radionuclides were calculated using the three previous equations. The following table lists the results of these calculations:

Radiation Dose Rates to Ecological Receptors from 1 pCi/g of Radium-226 in Equilibrium with its Eight Daughters

			External Dose Rate		Inhalation
	E_i	DF	Below Ground	Above Ground	Dose Rate
Nuclide	(MeV/nt)	(Sv-m3/Bq-s)	(mrad/d)	(mrad/d)	(mrad/d)
Ra-226	0.007	1.65E-19	3.8 E-4	1.2 E-4	6.0 E-7
Rn-222	0	1.14E-20	0	8.2 E-6	0
Po-218	0	2.63E-22	0	1.9 E-7	0
Pb-214	0.25	6.70E-18	1.3 E-2	4.8 E-3	1.1 E-6
Bi-214	1.508	4.36E-17	8.1 E-2	3.1 E-2	6.4 E-6
Po-214	0	2.40E-21	0	1.7 E-6	0
		Series Total	9.5 E-2	3.6 E-2	8.1 E-6

A dose rate limit of 1000 mrad/d is generally considered protective of plants and invertebrate populations (Sample et al. 1997). Using the external dose rate results for below ground exposures, the concentration threshold value of 10,500 pCi/g for plants and invertebrates was calculated using the following equation:

$$C_{Limit} = \frac{Dose_{Limit}}{Dose\ Rate} = \frac{1000\ mrad/d}{0.095\ mrad - g/d - pCi} = 10{,}500\ pCi/g \quad \text{Eq. A.7-17}$$

where:

C_{Limit} = Concentration limit of radium-226 to ecological receptor (mrad/d)
$Dose_{Limit}$ = Dose limit to ecological receptor (mrad/d)
Dose Rate = Dose rate from a full day of underground exposure (mrad-g/pCi-d)

The dose limit of 100 mrad/d is unlikely to cause observable changes in terrestrial vertebrate populations (Sample et al. 1997). This dose rate guideline was compared to the dose rate calculated for a small burrowing mammal. To be conservative, a small mammal spending 50% of its time underground was selected for calculating the concentration threshold for vertebrates. Exposures to this animal include external radiation while above ground, external radiation while below ground, ingestion of contaminated soil and food, and inhalation pathways. Currently, there is not enough information available to assess ingestion doses, but based on human experience, ingestion doses to fauna will be small compared to external doses.

The concentration limit of 1,500 pCi/g for small mammals was calculated using the following equation:

$$C_{Limit} = \frac{Dose_{Limit}}{\left(Dose\ Rate_{External\ Below\ Ground} \cdot EF_a + Dose\ Rate_{External\ Above\ Ground} \cdot EF_b\right) + Dose\ Rate_{Inhalation}}$$

Eq. A.7- 168

$$C_{Limit} = \frac{100\ mrad/d}{\left(0.095\ mrad - g/d - pCi \cdot 0.5\ d/d + 0.036\ mrad - g/d - pCi \cdot 0.5\ d/d\right) + 0.00015\ mrad - g/d - pCi}$$

Eq. A.7- 179

where:

EF_a = fraction of time spent above ground (0.5)
EF_b = fraction of time spent below ground (0.5)

The maximum concentrations of radium-226 in Area 1 and the Ford Property are below the more restrictive of these two threshold concentrations (1500 pCi/g for vertebrates). Therefore, radiological risks to ecological receptors in these two areas were judged to be within acceptable levels. The maximum concentration of radium-226 in Area 2 is 3,720 pCi/g. This is above the threshold concentration for vertebrates, but below the threshold concentration for plants and invertebrates (10,500 pCi/g).

A.7.5 UNCERTAINTIES IN THE ERA

The interpretation of risk estimates is subject to a number of uncertainties that result from the use of assumptions and the lack of information to quantify actual exposure and effects. The uncertainties associated with the ERA include those arising from:

- Collection and analysis of samples,
- Exposure assessment,
- Effects assessment, and
- Risk characterization.

A.7.5.1 Uncertainties Associated with the Collection and Analysis of Samples

Uncertainties associated with the collection and laboratory analysis of the sampling data may impact the results of the selection process. These uncertainties have been previously discussed in Section A.6.2 and will not be discussed here.

A.7.5.2 Uncertainties in the Exposure Assessment

A conservative approach was used in the exposure assessment to estimate potential doses or exposure concentrations for ecological receptors. The maximum concentration was used for the exposure concentration in abiotic media. This would overestimate potential direct exposure of ecological receptors. In Area 1, one sample WL-114 had chemical concentrations well above the other samples (many were over an order of magnitude higher than the next highest concentration) and may represent an anomalous sample. Therefore chemical concentrations from this sample would not be representative of the exposure concentrations for ecological populations. The total HIs for the ecological receptors would decrease significantly if this one sample was removed

from the data set. The HIs for plants and invertebrates would decrease from 547 and 153, to 105 and 25 respectively. The HIs for small mammals would decrease by over an order of magnitude. The HI for the white-footed mouse would decrease from 3,320 to 25. The HI for the cottontail rabbit would decrease from 5,750 to 74. The HI for the American robin would decrease by over two orders of magnitude (from 16,000 to 69). Similarly Area 2 has one selenium concentration which is over an order of magnitude greater than the other concentrations. One sample has a concentration of 38.0 mg/kg as compared to the next highest sample (1.0 mg/kg) and six other samples with concentrations of less than 1.0 mg/kg. If this outlying concentration was removed from the data set, the total HIs for small mammals and passerine birds would be significantly less. The HI for the white-footed mouse would decrease from 647 to 258 and the HI for the cotton-tail rabbit would decrease from 1,700 to 385. The HI for the American robin would decrease from 15,300 to 1,780.

The concentration of contaminants in food sources was likely to be overestimated because the maximum detected concentration was used as the source concentration. In estimating uptake of metals, the maximum BCF or the 90 percentile value for those chemicals which had values greater than 100, were used. The BCFs used in the assessment are likely to be greater than the actual values. For example, the BCFs for selenium in plants can vary by over four orders of magnitude. Some plants are selenium accumulators and bioaccumulate selenium in concentrations over 1,000 mg/kg. However, these plants are generally indigenous to the semi-arid regions of North America. The major selenium-accumulating plants are certain species of *Astragalus*, *Xylorrhiza*, *Oonopsis*, and *Stanleya* (Wilber 1983). None of these plants are present on site. Given the local climate, it is unlikely that any selenium bioaccumulating plants are present in the area.

Multiplying the maximum concentration by a maximum BCF, increases the probability that concentrations used to evaluate the potential risks are greater than the actual concentrations. This is especially true when evaluating potential risks associated with bioaccumulation within a food chain. Exposure via food often accounted for over 95% of the exposure to chemicals of concern in animals. Exposure via bioaccumulation into food is likely to be the result of using conservative values to estimate the concentration of the contaminants in food. The actual exposure concentrations are likely to be significantly less.

For higher predators (red fox and red-tailed hawk), the maximum BCFs for several organisms would be multiplied, further increasing the amount of conservatism in the exposure estimate. Exposure via bioaccumulation in prey items accounted for over 70% of the potential exposure. This is likely the result of overestimating the exposure concentrations in the prey items. For the red-tailed hawk, food accounted for over 79% of the exposure to selenium. This was primarily the result of consuming herbivores that are exposed to theoretically elevated concentrations of selenium in plants. As previously discussed, the maximum concentrations of selenium are over an order of magnitude higher than the next highest concentration for both areas. In addition, the BCF values for plants are likely to be over an order of magnitude greater than the actual value. Therefore the selenium HQ for the red-tailed hawk (11.9), may be over two orders of magnitude greater than the actual value.

A.7.5.3 Uncertainties in the Effects Assessment

The assessment of effects to site-specific receptor species uses toxicity data derived from test species data. These species may differ with respect to absorption, metabolism, distribution, and excretion of chemicals. The magnitude of the uncertainty will vary with each chemical. The benchmark values are conservative (Suter, personal communication). The endpoints for the NOAEL used in deriving the benchmark values are often not significant in terms of the adverse effects resulting in the decrease in a wildlife population. Changes in enzyme levels or histological changes are toxicological effects, but may not affect the ability of an organism to obtain food and reproduce.

Some chemicals did not have toxicity data available for some or all of the ecological receptors; therefore, these chemicals could not be evaluated. This would result in a potential underestimation of potential risks.

A.7.5.4 Uncertainties in the Risk Characterization

Ecological risks have been evaluated only for individual receptors in Operable Unit 1. Effects on individual organisms may occur with little population- or community-level effects. However, as the number of affected individuals increases, the likelihood of population-level effects increases.

There are uncertainties associated with the effect of decreased prey item populations on predatory receptors. Adverse population effects to prey items may reduce the foraging

population for predatory receptors, but may not necessarily adversely impact the population of predatory species.

The assumption that effects are additive ignores potential synergistic or antagonistic effects and adds significant uncertainty. Compounds may induce toxic effects in different organs or systems. Assuming similarity in mechanism of action may not be appropriate.

The HI assumes that the toxicity for all contaminants is additive (i.e., these contaminants act upon the same target organ and the contaminants do not have any synergistic or antagonistic effects). The potential for synergistic or antagonistic effects is difficult to evaluate given the number of contaminants involved; however, ignoring these potential actions adds significant uncertainty. The assumption that all contaminants act upon the same target organs is conservative. Given the different chemical classes and the presence of inorganics that often have different target organs, it is unlikely that all the contaminants will act upon a single target organ.

A.7.6 CONCLUSIONS

The purpose of the screening level risk assessment is to determine if a potential for adverse impacts to ecological receptors from exposure to COPCs exist at a site, and to determine which chemicals and exposure pathways are driving the potential risk or present the greatest potential risk. There is a significant amount of uncertainty associated with the actual potential for ecological impacts. A screening level risk assessment deals with the uncertainty by using highly conservative assumptions when estimating potential risks. This insures identification of sites for which no possible potential risk to ecological receptors exists and allows those sites to be separated from sites that may produce a potential risk to ecological receptors exposed to contaminants at the site. Therefore, if the screening risk assessment indicates that a potential risk does exist, this does not mean that site-related chemicals are impacting ecological receptors.

The results of the screening risk assessment for Operable Unit 1 indicate that ecological receptors may be at risk from exposure to chemical contaminants, especially metals, in both Areas 1 and 2. Small burrowing animals may be at risk from exposure to radioactive materials in Area 2. The results of the risk assessment indicate that metals present in soils may adversely affect plants and soil invertebrates. However, both Areas 1 and 2 currently support vegetative and animal

communities and there is no observable impact to the health of the plant communities.

Uptake of metals and bioaccumulation in the food chain may effect higher organisms. Based on the models used in this risk assessment, risk to ecological receptors may result from the bioaccumulation of metals in plants and earthworms. Exposure via food sources was the predominant exposure pathway for primary consumers. Exposure of predators was directly related to the concentrations of chemicals in plants and/or earthworms and the proportion of these contaminated food sources in the diet of prey organisms.

Selenium was the only chemical of concern for the red-tailed hawk. Exposure to all other contaminants present at the site are not likely to have an adverse effect upon this animal (HI = 0.3). Exposure to selenium was primarily the result of bioaccumulation of the chemical in the food. Food accounts for over 99% of the exposure of this hawk and the relative contributions from the various prey items are proportional to the amount of vegetation in the prey item's diet. The uptake of selenium in plants is likely to be overestimated because the bioaccumulation factor used was more representative of selenium bioaccumulating plants, which are not found at this site. The actual selenium concentrations in plants are likely to be orders of magnitude lower. The use of maximum BCF values for prey organisms is likely to have resulted in an even greater overestimation of exposure of predators. Therefore, the exposure of the red-tailed hawk is not likely to be greater than acceptable limits, and raptors are not at potential risk from exposure to contaminants in Operable Unit 1.

Selenium was the predominant chemical contaminant of concern in both Areas 1 and 2. This chemical was the predominant risk driver for the white-footed mouse, cottontail rabbit, and the American robin. It was one of the predominant risk drivers for the red fox and the American woodcock. The primary exposure pathway was bioaccumulation of the contaminant within the food chain, especially uptake by plants. Exposure via food accounted for 97% or greater of the selenium exposure in small mammals, over 99% in the American robin, and over 70% in the American woodcock and the red fox. The potential exposure of higher predators was often dependent on the proportion of herbivores in the predator's diet. As was previously discussed, the uptake of selenium in plants is likely to be overestimated because the BCF used was more representative of selenium bioaccumulating plants, which are not found at this site. The actual selenium concentrations in plants are likely to be orders of magnitude lower. The use of

maximum BCF values for prey organisms is likely to have resulted in an even greater overestimation of exposure of predators.

Exposure via uptake into food sources was the predominant exposure pathway for many of the organisms. Bioconcentration of contaminants accounted for over 95% of the exposure to the major risk drivers for the majority of the contaminants. The use of maximum BCF values is likely to result in an overestimation of actual exposure concentrations. The BCF values for many compounds vary by orders of magnitude. This coupled with the use of maximum measured concentrations provides the maximum possible exposure. However, this type of exposure is not representative of the populations present at the site. Therefore, the actual risks are well below the estimated values.

It should also be noted that these areas are located within a landfill operation. Some of the ecosystems present are the result of institutional controls that restrict access to Operable Unit 1 and allow field succession to occur. Landfill operations and remediation of Operable Unit 1 may significantly alter or destroy the habitats that currently exist, forcing wildlife present to migrate to other areas. The increasing commercial/industrial development of the land surrounding the West Lake Landfill has removed significant amounts of wildlife habitat. This decreasing habitat area will likely result in larger species leaving the area and reducing the overall ability of the area to support some types of wildlife.

TABLE A.7-1
PLANT SPECIES IDENTIFIED AT THE WEST LAKE LANDFILL

Scientific Name	Common Name	Area 1	Area 2	North Flood Control Channel	West Flood Control Channel	Ford Property
			Trees/Shrubs			
Acer negundo	Box elder		X			X
Cercis canadensis	Red Bud		X			
Cornus amomum	Silky dogwood		X	X		
Fraxinus spp.	Ash		X	X		
Morus spp.	Mulberry		X			
Populus deltoides	Eastern Cottonwood		X	X		X
Rhus syphina	Staghorn Sumac		X	X		X
Salix amygdaloides	Peached-leaved willow		X			
Salix spp.	Willow		X	X		
			Woody Vines			
Toxicodenaron radicans	Poison ivy		X	X		X
Viris spp.	Grape		X	X		X
			Herbs and Grasses			
Andropogon spp.	Bluestem	X				
Ambrosia spp.	Ragweed					X

Scientific Name	Common Name	Area 1	Area 2	North Flood Control Channel	West Flood Control Channel	Ford Property
Asceipias syriaca	Common milkweed		X			
Carduus crispus	Nodding thistle	X	X			X
Daucus carota	Wild carrot		X			
Erigeron annuus	Daisy fleabane		X			X
Gailium spp.	Bedstraw		X	X		
Graminae	Unknown Grasses	X	X	X	X	X
Impateins capensis	Jewelweed		X			
Juncus spp.	Rush	X				
Meiiiocus alba	White sweet clover		X			
Opuntia compressa	Prickly pear		X			
Phytoiacea americana	Pokeweed		X	X		
Plantago major	Common plantian	X				X
Polygonum spp.	Smartweed					X
Rumex crispus	Curied-dock	X	X			X
Solidago spp.	Goldenrod	X	X			X
Setaria spp.	Foxtail	X	X			X
Thiaspi arvense	Field pennycress	X	X			X

Scientific Name	Common Name	Area 1	Area 2	North Flood Control Channel	West Flood Control Channel	Ford Property
Trifolium pratense	Red clover		X			
Trifolium procumbens	Yellow sweet clover		X			X
Typha spp.	Cattails	X	X			
Vicia cracca	Cow vetch		X			X

TABLE A.7-2
List of Chemicals of Potential Concern

	Area 1			Area 2			
Chemical	Surface Soils (0 - 2 ft)	Near-surface Soils (0 - 5 ft)	Surface Water	Surface Soils (0 - 2 ft)	Near-surface Soils (0 - 5 ft)	Surface Water	Seep
Inorganics							
Antimony		X					
Arsenic	X	X		X	X	X	
Beryllium	X	X		X	X	X	
Cadmium	X	X		X	X	X	
Chromium	X	X		X	X	X	
Copper	X	X		X	X	X	
Cyanide		X					
Lead	X	X		X	X	X	X
Mercury	X	X		X	X	X	
Nickel	X	X		X	X	X	
Selenium	X	X		X	X	X	
Thallium	X	X					
Uranium	X	X		X	X	X	X
Zinc	X	X		X	X	X	X
Organics							
Acetone	X	X		X	X	X	
Benzene							X
Bis(2-ethylhexyl)phtha	X	X		X	X	X	
Butyl benzyl phthalate		X					
Chlorobenzene		X					X
Di-n-butylphthalate		X				X	
2,4-Dimethylphenol			X				
Di-n-octylphthalate	X	X		X	X		
1,2-Dichlorobenzene		X					
1,4-Dichlorobenzene	X	X		X	X	X	X
Ethyl benzene		X	X				
Fluoranthene		X		X	X	X	
Flourene		X					
2-Metylnaphthalene		X					
Naphthalene		X					
Phenanthrene		X					
Pyrene		X					
Toluene		X					
Xylenes	X	X	X	X	X	X	
Pesticides/PCBs							
Aldrin		X		X	X		
Aroclor 1242		X					
Aroclor 1254	X	X		X	X		
4,4'-DDD		X		X	X		
4,4'-DDE		X					
4,4'-DDT		X		X	X		
Dieldrin		X					
Endosulfan I		X					
Endrin		X					

TABLE A.7-3
Summary of Exposure Pathways for Ecological Receptors

Taxa	Direct Contact	Ingestion Soils	Ingestion Vegetation	Ingestion Invertebrates	Ingestion Prey Mammals	Ingestion Prey Birds	Ingestion Water
Plants	X						
Soil Invertebrates	X						
White-footed Mouse		X	X	X			X
Cottontail Rabbit		X	X				X
Red Fox		X	X	X	X	X	X
American Robin		X	X	X			X
American Woodcock		X		X			X
Red-tailed Hawk					X	X	X

TABLE A.7-4
Bioconcentration Factors (BCFs) for Plants

Chemical	log, K_{ow} [1]	BCF [2]	Bioconcentration Factors Summary from Literature: Number of Data Entries	Minimum BCF	90th Percentile BCF	Maximum BCF
Inorganics						
Antimony		2.00E-01 [3]				
Arsenic		1.21E+00	110	5.60E-05	1.22E+00	9.07E+00
Beryllium		1.00E-02 [3]				
Cadmium		4.60E+00	289	1.59E-02	4.60E+00	3.59E+01
Chromium		7.50E-03 [3]				
Copper		8.96E+00	41	3.90E-02	NA	8.96E+00
Cyanide		1.75E+01 [3]				
Lead		6.15E-01	204	1.13E-04	6.15E-01	1.06E+01
Mercury		9.00E-01 [3]				
Nickel		1.67E+00	163	6.32E-04	1.67E+00	2.22E+01
Selenium		2.63E+01	237	3.34E-02	2.63E+01	6.27E+02
Thallium		4.00E-03 [3]				
Uranium		8.50E-03 [3]				
Zinc		2.42E+00	24	1.50E-01	NA	2.42E+00
Organics						
Acetone	-0.24	1.07E+01				
Bis(2-ethylhexyl)phthalat	5.1	8.73E-03				
Butyl benzyl phthalate	4.9	1.14E-02				
Chlorobenzene	2.8	1.86E-01				
Di-n-butylphthalate	5.2	7.65E-03				
2,4-Dimethylphenol	2.42	3.09E-01				
Di-n-octylphthalate	9.2	3.73E-05				
1,2-Dichlorobenzene	3.38	8.62E-02				
1,4-Dichlorobenzene	3.39	8.50E-02				
Ethyl benzene	3.2	1.10E-01				
Fluoranthene	4.95	1.07E-02				
Flourene	4.18	2.97E-02				
2-Metylnaphthalene	-1.9	9.71E+01				
Methylene Chloride	1.25	1.47E+00				
Naphthalene	3.6	6.43E-02				
Phenanthrene	4.5	1.94E-02				
Pyrene	5.3	6.69E-03				
Toluene	2.7	2.13E-01				
Xylenes	3.2	1.10E-01				
Pesticides/PCBs						
Aldrin	3	1.43E-01				
Aroclor 1242	6	2.64E-03				
Aroclor 1254	6	2.64E-03				
4,4'-DDD	6	2.64E-03				
4,4'-DDE	5.7	3.93E-03				
4,4'-DDT	6.4	1.55E-03				
Dieldrin	4.6	1.70E-02				
Endosulfan I	3.6	6.43E-02				
Endrin	5.6	4.49E-03				
Beta BHC	3.8	4.93E-02				

[1] K_{ow} - octanol-water partitioning factor

[2] BCF for metals taken from literature; BCF for organics estimated using:
log BCF = 1.588 - 0.578 (log K_{ow}) (Travis and Arms 1988)

[3] Value from Baes et al. 1984.

References:
Sample et al. 1997, Sadiq 1985, Miles and Parker 1979, Heggo and Angle 1990, Lagerwerff 1971, and Burton and Morgan 1984

TABLE A.7-5
Bioconcentration Factors (BCFs) for Invertebrates

Chemical	log, K_{ow} [1]	BCF [2]	Bioconcentration Factors Summary from Literature			
			Number of Data Entries	Minimum BCF	90th Percentile BCF	Maximum BCF
Inorganics						
Antimony		1.30E-01	4	4.20E-02	NA	1.30E-01
Arsenic		9.25E-01	36	1.64E-02	NA	9.25E-01
Beryllium		ND [3]				
Cadmium		6.60E+01	113	4.29E-01	6.60E+01	1.90E+02
Chromium		5.37E+00	48	2.12E-02	NA	5.37E+00
Copper		2.28E+00	103	1.30E-02	2.28E+00	4.89E+00
Cyanide		ND				
Lead		4.32E+00	119	7.00E-04	4.32E+00	2.28E+02
Mercury		3.30E+01	15	4.88E-02	NA	3.30E+01
Nickel		2.28E-01	17	3.33E-02	NA	2.83E+00
Selenium		7.60E-01				
Thallium		8.50E-02	4	1.00E-02	NA	8.50E-02
Uranium		ND				
Zinc		2.50E+01	123	2.47E-02	2.50E+01	4.95E+01
Organics						
Acetone	-0.24	4.28E-01				
Bis(2-ethylhexyl)phthalat	5.1	7.92E-01				
Butyl benzyl phthalate	4.9	7.73E-01				
Chlorobenzene	2.8	6.07E-01				
Di-n-butylphthalate	5.2	8.01E-01				
2,4-Dimethylphenol	2.42	5.81E-01				
Di-n-octylphthalate	9.2	1.27E+00				
1,2-Dichlorobenzene	3.38	6.49E-01				
1,4-Dichlorobenzene	3.39	6.50E-01				
Ethyl benzene	3.2	6.36E-01				
Fluoranthene	4.95	7.78E-01				
Flourene	4.18	7.12E-01				
2-Metyinaphthalene	-1.9	3.54E-01				
Methylene Chloride	1.25	5.08E-01				
Naphthalene	3.6	6.66E-01				
Phenanthrene	4.5	7.39E-01				
Pyrene	5.3	8.10E-01				
Toluene	2.7	6.00E-01				
Xylenes	3.2	6.36E-01				
Pesticides/PCBs						
Aldrin	3	6.22E-01				
Aroclor 1242	6	8.78E-01				
Aroclor 1254	6	8.78E-01				
4,4'-DDD	6	8.78E-01				
4,4'-DDE	5.7	8.48E-01				
4,4'-DDT	6.4	9.19E-01				
Dieldrin	4.6	7.47E-01				
Endosulfan I	3.6	6.66E-01				
Endrin	5.6	8.38E-01				
Beta BHC	3.8	6.81E-01				

[1] K_{ow} - octanol-water partitioning factor

[2] BCF for metals taken from literature; BCF for organics estimated using: BCF = 0.44 (Kow)0.05 (Connell 1990).

[3] ND = No data.

References: Sample et al. 1997, and Helmke 1979

TABLE A.7-6
Bioconcentration Factors (BCFs) for Mammals and Birds

Chemical	log K_{ow} [1]	Mammal BCF [2]	Bird BCF [3]	Bioconcentration Factors Summary from Literature: Number of Data Entries	Minimum BCF	90th Percentile BCF	Maximum BCF
Inorganics							
Antimony		3.40E-06 [4]	3.40E-06				
Arsenic		7.10E-02	7.10E-02	72	0.00E+00	NA	7.10E-02
Beryllium		3.40E-06 [4]	3.40E-06				
Cadmium		3.99E+00	6.96E+01	100	1.53E-02	3.99E+00	6.96E+01
Chromium		8.00E-01	8.00E-01	38	3.14E-02	NA	8.00E-01
Copper		1.40E+00	1.40E+00	76	4.40E-03	NA	1.40E+00
Cyanide		ND	ND				
Lead		2.86E-01	2.86E-01	138	3.10E-03	2.86E-01	2.66E+00
Mercury		1.05E+00	1.05E+00	18	1.83E-02	NA	1.05E+00
Nickel		1.14E+00	1.14E+00	43	0.00E+00	NA	1.14E+00
Selenium		1.75E+00	1.75E+00	35	0.00E+00	NA	1.75E+00
Thallium		1.23E+01	1.23E-01	2	1.02E-01	NA	1.23E-01
Uranium		6.80E-07 [4]	6.15E-04				
Zinc		2.69E+00	1.64E+01	103	5.10E-03	2.59E+00	1.64E+01
Organics							
Acetone	-0.24	5.03E-05	6.70E-04				
Bis(2-ethylhexyl)phthalate	5.1	9.92E-02	5.25E-01				
Butyl benzyl phthalate	4.9	7.47E-02	4.09E-01				
Chlorobenzene	2.8	3.78E-03	2.98E-02				
Di-n-butylphthalate	5.2	1.14E-01	5.95E-01				
2,4-Dimethylphenol	2.42	2.20E-03	1.85E-02				
Di-n-octylphthalate	9.2	3.36E+01	8.76E+01				
1,2-Dichlorobenzene	3.38	8.62E-03	6.14E-02				
1,4-Dichlorobenzene	3.39	8.74E-03	6.21E-02				
Ethyl benzene	3.2	6.67E-03	4.90E-02				
Fluoranthene	4.95	8.02E-02	4.35E-01				
Flourene	4.18	2.69E-02	1.67E-01				
2-Metylnaphthalene	-1.9	4.76E-06	8.44E-05				
Methylene Chloride	1.25	4.18E-04	4.30E-03				
Naphthalene	3.6	1.18E-02	8.08E-02				
Phenanthrene	4.5	4.23E-02	2.48E-01				
Pyrene	5.3	1.32E-01	6.74E-01				
Toluene	2.7	3.28E-03	2.63E-02				
Xylenes	3.2	6.67E-03	4.90E-02				
Pesticides/PCBs							
Aldrin	3	5.02E-03	3.82E-02				
Aroclor 1242	6	3.56E-01	1.61E+00				
Aroclor 1254	6	3.56E-01	1.61E+00				
4,4'-DDD	6	3.56E-01	1.61E+00				
4,4'-DDE	5.7	2.33E-01	1.11E+00				
4,4'-DDT	6.4	6.29E-01	2.66E+00				
Dieldrin	4.6	4.88E-02	2.81E-01				
Endosulfan I	3.6	1.18E-02	8.08E-02				
Endrin	5.6	2.02E-01	9.80E-01				
Beta BHC	3.8	1.57E-02	1.04E-01				

[1] K_{ow} = octanol-water partitioning factor

[2] *BCF for metals taken from literature; BCF for organics estimated using:*
log BCF for fat = -3.849 + 0.617 (log K_{ow}) (Garten and Trablaka 1983). Assumed mammal tissue consisted of 50% fat.

[3] Mammalian values used for metals; BCF for organics estimated using
log BCF for fat = -2.743 + 0.542 (log K_{ow}) (Garten and Trablaka 1983). Assumed bird tissue consisted of 50% fat.

[4] Value from Baes et al. 1984.

References:

Andrews et al. 1984, Andrews et al. 1989a, Andrews et al. 1989b, Beyer et al. 1985, Beyer et al. 1990, Cloutier et al. 1985, DOE 1995, Elfving et al. 1979, Goldsmith et al. 1976, Goldsmith and Scanlon 1977, Hunter and Johnson 1982, Hunter et al. 1989, Johnson et al. 1978, Ma et al. 1991, Pascoe et al. 1994, Pascoe et al. 1996, Quarles et al. 1974, Read and Martin 1993, Roberts et al. 1978, Scanlon 1987, Shore 1995, Talmage et al. 1991, and Talmage and Walton 1993.

TABLE A.7-7
Natural History Parameters for Ecological Receptors

Wildlife Species	Body Weight (kg)	Food Ingestion (kg/d)	Diet Composition (Food Type)	Amount	Water Ingestion (L/d)	Soil Ingestion (kg/d)	Home Range (acres)	HR Factor Area 1	HR Factor Area 2
White-footed mouse	2.20E-02	3.40E-03	Invertebrates	4.55E-01	6.60E-03	6.80E-05		1.00E+00	1.00E+00
			Vegetation	4.95E-01					
Cottontail Rabbit	1.20E+00	2.37E-01	Vegetation	1.00E+00	1.16E-01	1.50E-02	3.70E+00	1.00E+00	1.00E+00
Red Fox	4.50E+00	4.50E-01	Rabbits	4.30E-01	3.80E-01	1.26E-02	2.37E+02	4.22E-02	1.27E-01
			Mice	2.80E-01					
			Birds	1.40E-01					
			Invertebrates	3.00E-02					
			Vegetation	1.20E-01					
American Robin	7.70E-02	9.30E-02	Invertebrates	3.75E-01	1.06E-02	1.90E-03	2.60E+01	3.85E-01	1.00E+00
			Vegetation	6.25E-01					
American Woodcock	1.98E-01	1.50E-01	Invertebrates	1.00E+00	2.00E-02	1.56E-02	9.44E+01	1.06E-01	3.18E-01
Red-tailed hawk	1.13E+00	1.09E-01	Rabbits	6.75E-01	6.40E-02	0.00E+00	5.50E+02	1.82E-02	5.45E-02
			Mice	6.00E-02					
			Birds	2.65E-01					

Table A.7-8 Exposure Concentrations in Abiotic Media and Biota - Area 1

Chemical	Surface Soil (mg/kg)	Near Surface Soil (mg/kg)	Surface Water (mg/L)	Plant (mg/kg)	Invertebrate (mg/kg)	White-footed Mouse (mg/kg)	Cottontail Rabbit (mg/kg)	American Robin (mg/kg)
Inorganics								
Antimony	0.00E+00	4.80E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.13E-07	0.00E+00
Arsenic	2.20E+02	2.20E+02	0.00E+00	2.66E+02	2.04E+02	1.52E+00	6.62E-01	5.31E-02
Beryllium	3.30E+00	3.30E+00	0.00E+00	3.30E-02	0.00E+00	5.18E-08	8.96E-08	6.77E-09
Cadmium	7.90E+00	7.90E+00	0.00E+00	2.84E+02	5.21E+02	4.66E+02	1.24E+02	6.47E+01
Chromium	3.10E+01	2.80E+02	0.00E+00	2.33E-01	1.66E+02	1.88E+01	1.56E+00	4.26E+00
Copper	2.30E+03	2.30E+03	0.00E+00	2.06E+04	5.24E+03	5.46E+03	3.17E+03	2.05E+02
Cyanide	0.00E+00	1.10E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Lead	3.20E+02	9.00E+02	0.00E+00	1.97E+02	1.38E+03	6.54E+01	8.02E+00	6.78E+01
Mercury	1.70E-01	1.70E-01	0.00E+00	1.53E-01	5.61E+00	8.54E-01	1.87E-02	1.96E-01
Nickel	3.60E+03	3.60E+03	0.00E+00	2.16E+02	8.21E+02	1.82E+02	5.51E+01	6.31E+00
Selenium	2.50E+02	2.50E+02	0.00E+00	6.58E+03	1.90E+02	1.30E+03	9.05E+02	5.07E+01
Thallium	1.20E+00	1.20E+00	0.00E+00	4.80E-03	1.02E-01	2.31E-03	1.08E-03	1.07E-05
Uranium	4.38E+02	4.38E+02	0.00E+00	3.72E+00	0.00E+00	1.31E-06	2.33E-06	4.45E-04
Zinc	1.20E+02	5.60E+02	0.00E+00	2.90E+02	3.00E+03	1.26E+03	9.55E+01	6.21E+02
Organics								
Acetone	3.40E-02	1.25E+01	0.00E+00	3.62E-01	1.46E-02	2.90E-06	6.33E-06	9.38E-06
Bis(2-ethylhexyl)pht	7.80E+00	2.30E+01	0.00E+00	6.81E-02	6.17E+00	8.96E-02	1.65E-02	6.65E-01
Butyl benzyl phthala	0.00E+00	1.80E+02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.27E-02	0.00E+00
Chlorobenzene	0.00E+00	2.50E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.52E-05	0.00E+00
Di-n-butylphthalate	0.00E+00	1.00E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.89E-03	0.00E+00
2,4-Dimethylphenol	0.00E+00	0.00E+00	7.50E-02	0.00E+00	0.00E+00	4.96E-05	8.81E-06	1.29E-07
Di-n-octylphthalate	3.00E+00	3.70E+00	0.00E+00	1.12E-04	3.81E+00	1.83E+01	8.58E-01	2.70E+01
1,2-Dichlorobenzen	0.00E+00	1.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.94E-08	0.00E+00
1,4-Dichlorobenzen	4.20E-02	2.50E+00	0.00E+00	3.57E-03	2.73E-02	3.95E-05	1.54E-04	7.82E-06
Ethyl benzene	0.00E+00	2.00E+01	2.20E-03	0.00E+00	0.00E+00	4.40E-06	9.21E-04	1.00E-08
Fluoranthene	0.00E+00	8.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.70E-04	6.00E-02
Flourene	0.00E+00	3.60E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.67E-05	0.00E+00
2-Methylnaphthalen	0.00E+00	4.40E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.44E-07	0.00E+00
Methylene Chloride	0.00E+00	2.70E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.78E-06	0.00E+00
Naphthalene	0.00E+00	4.70E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.82E-04	0.00E+00
Phenanthrene	0.00E+00	9.10E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.66E-04	0.00E+00
Pyrene	0.00E+00	8.50E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	7.73E-04	0.00E+00
Toluene	0.00E+00	2.90E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.56E-04	0.00E+00
Xylenes	3.70E-02	2.26E+02	1.30E-02	4.05E-03	2.35E-02	5.30E-05	1.04E-02	1.08E-05
Pesticides/PCBs								
Aldrin	0.00E+00	1.60E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.54E-06	1.13E-06
Aroclor 1242	0.00E+00	2.60E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	8.39E-03	0.00E+00
Aroclor 1254	1.10E+00	1.10E+00	0.00E+00	2.90E-03	9.66E-01	4.98E-02	2.82E-03	4.72E-02
4,4'-DDD	0.00E+00	1.50E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.69E-05	2.20E-04
4,4'-DDE	0.00E+00	3.40E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.46E-06	0.00E+00
4,4'-DDT	0.00E+00	6.30E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.73E-04	4.62E-04
Dieldrin	0.00E+00	4.20E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.41E-05	0.00E+00
Endosulfan I	0.00E+00	1.70E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.38E-07	0.00E+00
Endrin	0.00E+00	9.30E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.29E-05	0.00E+00
Beta BHC	0.00E+00	1.70E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.83E-06	0.00E+00

Table A.7-9 Exposure Concentrations in Abiotic Media and Biota - Area 2

Chemical	Surface Soil (mg/kg)	Near Surface Soil (mg/kg)	Surface Water (mg/L)	Plant (mg/kg)	Earthworm (mg/kg)	White-footed Mouse (mg/kg)	Cottontail Rabbit (mg/kg)	American Robin (mg/kg)
Inorganics								
Arsenic	3.50E+01	3.50E+01	4.24E+01	3.24E+01	3.24E+01	1.22E-01	1.91E-01	2.68E-02
Beryllium	2.20E+00	2.20E+00	2.20E-02	0.00E+00	0.00E+00	2.88E-08	1.08E-07	5.48E-09
Cadmium	6.30E+00	6.30E+00	2.26E+02	4.16E+02	4.16E+02	1.86E+02	1.79E+02	3.24E+01
Chromium	4.90E+01	4.90E+01	3.68E-01	2.63E+02	2.63E+02	1.49E+01	5.48E-01	2.14E+00
Copper	3.60E+02	3.60E+02	3.23E+03	8.21E+02	8.21E+02	4.28E+02	8.98E+02	1.03E+02
Lead	2.20E+03	2.20E+03	1.35E+03	9.50E+03	9.50E+03	2.27E+02	8.55E+01	3.41E+01
Mercury	2.70E-01	2.70E-01	2.43E-01	8.91E+00	8.91E+00	6.78E-01	5.39E-02	9.83E-02
Nickel	6.80E+02	6.80E+02	4.08E+01	1.55E+02	1.55E+02	1.84E+01	1.89E+01	3.40E+00
Selenium	3.80E+01	3.80E+01	9.99E+02	2.89E+01	2.89E+01	9.90E+01	2.49E+02	2.53E+01
Uranium	8.75E+02	8.75E+02	7.44E+00	0.00E+00	0.00E+00	2.23E-06	8.44E-06	3.69E-04
Zinc	4.00E+02	4.00E+02	9.68E+02	1.00E+04	1.00E+04	2.09E+03	5.28E+02	3.11E+02
Organics								
Acetone	3.80E-02	3.80E-02	4.05E-01	1.63E-02	1.63E-02	1.62E-06	4.05E-06	4.70E-06
Bis(2-ethylhexyl)phthalate	7.70E+01	7.70E+01	6.73E-01	6.09E+01	6.09E+01	4.54E-01	1.09E-01	3.43E-01
Di-n-octylphthalate	1.20E+01	1.20E+01	4.47E-04	1.52E+01	1.52E+01	3.72E+01	5.04E+00	1.38E+01
1,4-Dichlorobenzene	6.50E-03	6.50E-03	5.53E-04	4.23E-03	4.23E-03	3.14E-06	1.66E-06	4.04E-06
Fluoranthene	8.50E+00	8.50E+00	9.06E-02	6.61E+00	6.61E+00	4.00E-02	9.96E-03	3.10E-02
Xylenes	1.20E-02	1.20E-02	1.31E-03	7.63E-03	7.63E-03	4.50E-06	2.73E-06	5.60E-06
Pesticides/PCBs								
Aldrin	1.70E-03	1.70E-03	2.43E-04	1.06E-03	1.06E-03	4.93E-07	3.48E-07	5.84E-07
Aroclor 1254	1.60E+00	1.60E+00	4.22E-03	1.40E+00	1.40E+00	3.71E-02	7.43E-03	2.43E-02
4,4'-DDD	7.60E-03	7.60E-03	2.00E-05	6.67E-03	6.67E-03	1.76E-04	3.53E-05	1.13E-04
4,4'-DDT	9.30E-03	9.30E-03	1.44E-05	8.55E-03	8.55E-03	3.97E-04	7.49E-05	2.38E-04

Table A.7-10 Exposure Rates for White-Footed Mouse (mg/kg/day) - Area 1

Chemical	Environmenal Media		Biota			Total Exposure
	Soils	Water	Plant	Invertebrate	Total	
Inorganics						
Arsenic	6.80E-01	0.00E+00	2.04E+01	1.43E+01	3.47E+01	3.54E+01
Beryllium	1.02E-02	0.00E+00	2.52E-03	0.00E+00	2.52E-03	1.27E-02
Cadmium	2.44E-02	0.00E+00	2.17E+01	3.67E+01	5.84E+01	5.84E+01
Chromium	9.58E-02	0.00E+00	1.78E-02	1.17E+01	1.17E+01	1.18E+01
Copper	7.11E+00	0.00E+00	1.58E+03	3.69E+02	1.95E+03	1.95E+03
Lead	9.89E-01	0.00E+00	1.51E+01	9.72E+01	1.12E+02	1.13E+02
Mercury	5.25E-04	0.00E+00	1.17E-02	3.94E-01	4.06E-01	4.07E-01
Nickel	1.11E+01	0.00E+00	1.65E+01	5.77E+01	7.42E+01	8.54E+01
Selenium	7.73E-01	0.00E+00	5.03E+02	1.34E+01	5.16E+02	5.17E+02
Thallium	3.71E-03	0.00E+00	3.67E-04	7.17E-03	7.54E-03	1.12E-02
Uranium	1.35E+00	0.00E+00	2.84E-01	0.00E+00	2.84E-01	1.64E+00
Zinc	3.71E-01	0.00E+00	2.22E+01	2.11E+02	2.33E+02	2.34E+02
Organics						
Acetone	1.05E-04	0.00E+00	2.77E-02	1.02E-03	2.87E-02	2.89E-02
Bis(2-ethylhexyl)phthalate	2.41E-02	0.00E+00	5.21E-03	4.34E-01	4.39E-01	4.63E-01
2,4-Dimethylphenol	0.00E+00	2.25E-02	0.00E+00	0.00E+00	0.00E+00	2.25E-02
Di-n-octylphthalate	9.27E-03	0.00E+00	8.55E-06	2.68E-01	2.68E-01	2.77E-01
1,4-Dichlorobenzene	1.30E-04	0.00E+00	2.73E-04	1.92E-03	2.19E-03	2.32E-03
Ethyl benzene	0.00E+00	6.60E-04	0.00E+00	0.00E+00	0.00E+00	6.60E-04
Xylenes	1.14E-04	3.90E-03	3.10E-04	1.65E-03	1.96E-03	5.98E-03
Pesticides/PCBs						
Aroclor 1254	3.40E-03	0.00E+00	2.22E-04	6.79E-02	6.81E-02	7.15E-02
4,4'-DDD	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table A.7-11 Exposure Rates for Cottontail Rabbit (mg/kg/day) - Area 1

Chemical	Environmenal Media		Biota	Total
	Soils	Water	Plant	Exposure
Inorganics				
Antimony	3.31E-02	0.00E+00	0.00E+00	3.31E-02
Arsenic	1.52E+00	0.00E+00	2.90E+01	3.05E+01
Beryllium	2.28E-02	0.00E+00	3.60E-03	2.64E-02
Cadmium	5.45E-02	0.00E+00	3.09E+01	3.10E+01
Chromium	1.93E+00	0.00E+00	2.53E-02	1.96E+00
Copper	1.59E+01	0.00E+00	2.25E+03	2.26E+03
Cyanide	7.59E-03	0.00E+00	0.00E+00	7.59E-03
Lead	6.21E+00	0.00E+00	2.14E+01	2.76E+01
Mercury	1.17E-03	0.00E+00	1.67E-02	1.78E-02
Nickel	2.48E+01	0.00E+00	2.35E+01	4.84E+01
Selenium	1.72E+00	0.00E+00	7.16E+02	7.18E+02
Thallium	8.27E-03	0.00E+00	5.23E-04	8.80E-03
Uranium	3.02E+00	0.00E+00	4.05E-01	3.42E+00
Zinc	3.86E+00	0.00E+00	3.16E+01	3.55E+01
Organics				
Acetone	8.62E-02	0.00E+00	3.95E-02	1.26E-01
Bis(2-ethylhexyl)phthalate	1.59E-01	0.00E+00	7.42E-03	1.66E-01
Butyl benzyl phthalate	1.24E+00	0.00E+00	0.00E+00	1.24E+00
Chlorobenzene	1.72E-02	0.00E+00	0.00E+00	1.72E-02
Di-n-butylphthalate	6.90E-02	0.00E+00	0.00E+00	6.90E-02
2,4-Dimethylphenol	0.00E+00	4.00E-03	0.00E+00	4.00E-03
Di-n-octylphthalate	2.55E-02	0.00E+00	1.22E-05	2.55E-02
1,2-Dichlorobenzene	6.90E-06	0.00E+00	0.00E+00	6.90E-06
1,4-Dichlorobenzene	1.72E-02	0.00E+00	3.89E-04	1.76E-02
Ethyl benzene	1.38E-01	1.17E-04	0.00E+00	1.38E-01
Fluoranthene	5.86E-03	0.00E+00	0.00E+00	5.86E-03
Flourene	2.48E-03	0.00E+00	0.00E+00	2.48E-03
2-Methylnaphthalene	3.03E-02	0.00E+00	0.00E+00	3.03E-02
Methylene Chloride	1.86E-02	0.00E+00	0.00E+00	1.86E-02
Naphthalene	3.24E-02	0.00E+00	0.00E+00	3.24E-02
Phenanthrene	6.28E-03	0.00E+00	0.00E+00	6.28E-03
Pyrene	5.86E-03	0.00E+00	0.00E+00	5.86E-03
Toluene	2.00E-01	0.00E+00	0.00E+00	2.00E-01
Xylenes	1.56E+00	6.93E-04	4.41E-04	1.56E+00
Pesticides/PCBs				
Aldrin	1.10E-03	0.00E+00	0.00E+00	1.10E-03
Aroclor 1242	1.79E-02	0.00E+00	0.00E+00	1.79E-02
Aroclor 1254	7.59E-03	0.00E+00	3.16E-04	7.90E-03
4,4'-DDD	1.03E-04	0.00E+00	0.00E+00	1.03E-04
4,4'-DDE	2.34E-05	0.00E+00	0.00E+00	2.34E-05
4,4'-DDT	4.34E-04	0.00E+00	0.00E+00	4.34E-04
Dieldrin	2.90E-04	0.00E+00	0.00E+00	2.90E-04
Endosulfan I	1.17E-05	0.00E+00	0.00E+00	1.17E-05
Endrin	6.41E-05	0.00E+00	0.00E+00	6.41E-05
Beta BHC	1.17E-04	0.00E+00	0.00E+00	1.17E-04

Table A.7-12 - Exposure Rates for American Robin (mg/kg/day) - Area 1

Chemical	Environmenal Media		Biota			Total Exposure
	Soils	Water	Plant	Invertebrate	Total	
Inorganics						
Arsenic	4.26E-01	0.00E+00	1.58E+01	7.24E+00	2.30E+01	4.64E+01
Beryllium	6.39E-03	0.00E+00	1.96E-03	0.00E+00	1.96E-03	1.03E-02
Cadmium	1.53E-02	0.00E+00	1.68E+01	1.85E+01	3.53E+01	7.07E+01
Chromium	6.01E-02	0.00E+00	1.38E-02	5.92E+00	5.93E+00	1.19E+01
Copper	4.46E+00	0.00E+00	1.22E+03	1.86E+02	1.41E+03	2.82E+03
Lead	6.20E-01	0.00E+00	1.17E+01	4.92E+01	6.08E+01	1.22E+02
Mercury	3.29E-04	0.00E+00	9.07E-03	1.99E-01	2.09E-01	4.17E-01
Nickel	6.97E+00	0.00E+00	1.28E+01	2.92E+01	4.20E+01	9.09E+01
Selenium	4.84E-01	0.00E+00	3.90E+02	6.76E+00	3.96E+02	7.93E+02
Thallium	2.32E-03	0.00E+00	2.84E-04	3.63E-03	3.91E-03	1.01E-02
Uranium	6.84E-01	0.00E+00	1.78E-01	0.00E+00	1.78E-01	1.04E+00
Zinc	2.32E-01	0.00E+00	1.72E+01	1.07E+02	1.24E+02	2.48E+02
Organics						
Acetone	6.59E-05	0.00E+00	2.15E-02	5.17E-04	2.20E-02	4.41E-02
Bis(2-ethylhexyl)phthalate	1.51E-02	0.00E+00	4.04E-03	2.20E-01	2.24E-01	4.62E-01
2,4-Dimethylphenol	0.00E+00	8.11E-04	0.00E+00	0.00E+00	0.00E+00	8.11E-04
Di-n-octylphthalate	5.81E-03	0.00E+00	6.63E-06	1.35E-01	1.35E-01	2.77E-01
1,4-Dichlorobenzene	8.14E-05	0.00E+00	2.12E-04	9.71E-04	1.18E-03	2.45E-03
Ethyl benzene	0.00E+00	2.38E-05	0.00E+00	0.00E+00	0.00E+00	2.38E-05
Xylenes	7.17E-05	1.40E-04	2.40E-04	8.37E-04	1.08E-03	2.37E-03
Pesticides/PCBs						
Aroclor 1254	2.13E-03	0.00E+00	1.72E-04	3.43E-02	3.45E-02	7.11E-02

Table A.7-13 Exposure Rates for White-Footed Mouse (mg/kg/day) - Area 2

Chemical	Environmenal Media		Biota			Total Exposure
	Soils	Water	Plant	Invertebrate	Total	
Inorganics						
Arsenic	1.08E-01	0.00E+00	3.24E+00	2.28E+00	5.52E+00	5.62E+00
Beryllium	6.80E-03	0.00E+00	1.68E-03	0.00E+00	1.68E-03	8.48E-03
Cadmium	1.95E-02	0.00E+00	1.73E+01	2.92E+01	4.65E+01	4.66E+01
Chromium	1.51E-01	0.00E+00	2.81E-02	1.85E+01	1.85E+01	1.87E+01
Copper	1.11E+00	0.00E+00	2.47E+02	5.77E+01	3.04E+02	3.06E+02
Lead	6.80E+00	5.40E+00	1.04E+02	6.68E+02	7.72E+02	7.84E+02
Mercury	8.35E-04	0.00E+00	1.86E-02	6.27E-01	6.45E-01	6.46E-01
Nickel	2.10E+00	0.00E+00	3.12E+00	1.09E+01	1.40E+01	1.61E+01
Selenium	1.17E-01	0.00E+00	7.65E+01	2.03E+00	7.85E+01	7.86E+01
Uranium	2.70E+00	0.00E+00	5.69E-01	0.00E+00	5.69E-01	3.27E+00
Zinc	1.24E+00	0.00E+00	7.41E+01	7.03E+02	7.77E+02	7.78E+02
Organics						
Acetone	1.17E-04	0.00E+00	3.10E-02	1.14E-03	3.21E-02	3.22E-02
Bis(2-ethylhexyl)phthalate	2.38E-01	0.00E+00	5.14E-02	4.29E+00	4.34E+00	4.58E+00
Di-n-octylphthalate	3.71E-02	0.00E+00	3.42E-05	1.07E+00	1.07E+00	1.11E+00
1,4-Dichlorobenzene	2.01E-05	0.00E+00	4.23E-05	2.97E-04	3.39E-04	3.59E-04
Fluoranthene	2.63E-02	0.00E+00	6.93E-03	4.65E-01	4.72E-01	4.98E-01
Xylenes	3.71E-05	0.00E+00	1.01E-04	5.37E-04	6.37E-04	6.74E-04
Pesticides/PCBs						
Aldrin	5.25E-06	0.00E+00	1.86E-05	7.43E-05	9.29E-05	9.81E-05
Aroclor 1254	4.95E-03	0.00E+00	3.23E-04	9.88E-02	9.91E-02	1.04E-01
4,4'-DDD	2.35E-05	0.00E+00	1.53E-06	4.69E-04	4.71E-04	4.94E-04
4,4'-DDT	2.87E-05	0.00E+00	1.10E-06	6.01E-04	6.02E-04	6.31E-04

Table A.7-14 Exposure Rates for Cottontail Rabbit (mg/kg/day) - Area 2

Chemical	Environmenal Media		Biota	Total
	Soils	Water	Plant	Exposure
Inorganics				
Arsenic	4.38E-01	0.00E+00	8.36E+00	8.80E+00
Beryllium	2.75E-02	0.00E+00	4.35E-03	3.18E-02
Cadmium	7.88E-02	0.00E+00	4.47E+01	4.47E+01
Chromium	6.13E-01	0.00E+00	7.26E-02	6.85E-01
Copper	4.50E+00	0.00E+00	6.37E+02	6.42E+02
Lead	2.75E+01	0.00E+00	2.67E+02	2.95E+02
Mercury	3.38E-03	0.00E+00	4.80E-02	5.14E-02
Nickel	8.50E+00	0.00E+00	8.06E+00	1.66E+01
Selenium	4.75E-01	0.00E+00	1.97E+02	1.98E+02
Uranium	1.09E+01	0.00E+00	1.47E+00	1.24E+01
Zinc	5.00E+00	0.00E+00	1.91E+02	1.96E+02
Organics				
Acetone	4.75E-04	0.00E+00	8.00E-02	8.05E-02
Bis(2-ethylhexyl)phthalate	9.63E-01	0.00E+00	1.33E-01	1.10E+00
Di-n-octylphthalate	1.50E-01	0.00E+00	8.83E-05	1.50E-01
1,4-Dichlorobenzene	8.13E-05	0.00E+00	1.09E-04	1.90E-04
Fluoranthene	1.06E-01	0.00E+00	1.79E-02	1.24E-01
Xylenes	1.50E-04	0.00E+00	2.60E-04	4.10E-04
Pesticides/PCBs				
Aldrin	2.13E-05	0.00E+00	4.80E-05	6.92E-05
Aroclor 1254	2.00E-02	0.00E+00	8.33E-04	2.08E-02
4,4'-DDD	9.50E-05	0.00E+00	3.96E-06	9.90E-05
4,4'-DDT	1.16E-04	0.00E+00	2.84E-06	1.19E-04

Table A.7-15 Exposure Rates for American Robin (mg/kg/day) - Area 2

Chemical	Environmenal Media		Biota			Total Exposure
	Soils	Water	Plant	Invertebrate	Total	
Inorganics						
Arsenic	3.84E-01	0.00E+00	1.42E+01	6.53E+00	2.08E+01	2.11E+01
Beryllium	2.42E-02	0.00E+00	7.39E-03	0.00E+00	7.39E-03	3.16E-02
Cadmium	6.92E-02	0.00E+00	7.60E+01	8.38E+01	1.60E+02	1.60E+02
Chromium	5.38E-01	0.00E+00	1.23E-01	5.30E+01	5.32E+01	5.37E+01
Copper	3.95E+00	0.00E+00	1.08E+03	1.65E+02	1.25E+03	1.25E+03
Lead	2.42E+01	0.00E+00	4.55E+02	1.92E+03	2.37E+03	2.39E+03
Mercury	2.97E-03	0.00E+00	8.16E-02	1.80E+00	1.88E+00	1.88E+00
Nickel	7.47E+00	0.00E+00	1.37E+01	3.13E+01	4.50E+01	5.24E+01
Selenium	4.17E-01	0.00E+00	3.36E+02	5.82E+00	3.42E+02	3.42E+02
Uranium	2.72E+00	0.00E+00	7.08E-01	0.00E+00	7.08E-01	1.21E+01
Zinc	4.39E+00	0.00E+00	3.25E+02	2.02E+03	2.34E+03	2.35E+03
Organics						
Acetone	4.17E-04	0.00E+00	1.36E-01	3.28E-03	1.39E-01	1.40E-01
Bis(2-ethylhexyl)phthalate	8.46E-01	0.00E+00	2.26E-01	1.23E+01	1.25E+01	1.34E+01
Di-n-octylphthalate	1.32E-01	0.00E+00	1.50E-04	3.07E+00	3.07E+00	3.20E+00
1,4-Dichlorobenzene	7.14E-05	0.00E+00	1.86E-04	8.52E-04	1.04E-03	1.11E-03
Fluoranthene	9.33E-02	0.00E+00	3.05E-02	1.33E+00	1.36E+00	1.46E+00
Xylenes	1.32E-04	0.00E+00	4.41E-04	1.54E-03	1.98E-03	2.11E-03
Pesticides/PCBs						0.00E+00
Aldrin	1.87E-05	0.00E+00	8.16E-05	2.13E-04	2.95E-04	3.13E-04
Aroclor 1254	1.76E-02	0.00E+00	1.42E-03	2.83E-01	2.85E-01	3.02E-01
4,4'-DDD	8.35E-05	0.00E+00	6.73E-06	1.34E-03	1.35E-03	1.44E-03
4,4'-DDT	1.02E-04	0.00E+00	4.84E-06	1.72E-03	1.73E-03	1.83E-03

Table A.7-16 Exposure Rates for Red Fox (mg/kg/day)

Chemical	Environmenal Media		Biota						Total Exposure
	Soils	Water	Plant	Invertebrate	White-footed Mouse	Cottontail Rabbit	American Robin	Total	
Inorganics									
Antimony	1.34E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.17E-11	0.00E+00	4.17E-11	1.34E-02
Arsenic	7.14E-01	0.00E+00	5.23E-02	1.00E-02	6.97E-04	6.46E-04	4.27E-05	6.37E-02	7.78E-01
Beryllium	1.54E-02	0.00E+00	1.63E-05	0.00E+00	5.98E-11	2.61E-10	5.44E-12	1.63E-05	1.54E-02
Cadmium	3.98E-02	0.00E+00	1.62E-01	7.44E-02	6.20E-01	4.21E-01	5.20E-02	1.33E+00	1.37E+00
Chromium	9.21E-01	0.00E+00	2.39E-04	4.28E-02	4.52E-02	1.73E-03	3.42E-03	9.35E-02	1.01E+00
Copper	7.45E+00	0.00E+00	4.02E+00	2.56E-01	2.48E+00	3.06E+00	1.65E-01	9.98E+00	1.74E+01
Cyanide	3.08E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.08E-03
Lead	8.68E+00	0.00E+00	8.13E-01	1.43E+00	6.33E-01	1.82E-01	5.45E-02	3.11E+00	1.18E+01
Mercury	1.23E-03	0.00E+00	1.58E-04	1.45E-03	2.06E-03	1.20E-04	1.58E-04	3.95E-03	5.18E-03
Nickel	1.20E+01	0.00E+00	4.62E-02	4.39E-02	9.09E-02	6.00E-02	5.08E-03	2.46E-01	1.22E+01
Selenium	8.06E-01	0.00E+00	1.27E+00	9.14E-03	5.85E-01	8.58E-01	4.07E-02	2.76E+00	3.56E+00
Thallium	3.36E-03	0.00E+00	4.96E-07	2.64E-06	5.57E-07	4.01E-07	8.64E-09	4.10E-06	3.36E-03
Uranium	3.68E+00	0.00E+00	4.74E-03	0.00E+00	3.89E-09	1.86E-08	3.58E-07	4.74E-03	3.68E+00
Zinc	2.69E+00	0.00E+00	5.97E-01	1.54E+00	6.02E+00	1.14E+00	5.00E-01	9.81E+00	1.25E+01
Organics									
Acetone	3.51E-02	0.00E+00	2.75E-04	2.76E-06	5.13E-09	1.08E-08	7.54E-09	2.78E-04	3.54E-02
Bis(2-ethylhexyl)ph	2.80E-01	0.00E+00	4.01E-04	9.09E-03	1.23E-03	2.34E-04	5.35E-04	1.15E-02	2.91E-01
Butyl benzyl phthal:	5.04E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	3.43E-05	0.00E+00	3.43E-05	5.04E-01
Chlorobenzene	7.00E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.41E-08	0.00E+00	2.41E-08	7.00E-03
Di-n-butylphthalate	2.80E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.92E-06	0.00E+00	2.92E-06	2.80E-02
2,4-Dimethylphenol	0.00E+00	5.45E-05	0.00E+00	0.00E+00	1.20E-08	3.26E-09	1.04E-10	1.53E-08	5.46E-05
Di-n-octylphthalate	4.40E-02	0.00E+00	2.74E-07	2.33E-03	1.05E-01	1.09E-02	2.17E-02	1.39E-01	1.83E-01
1,2-Dichlorobenzen	2.80E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.20E-11	0.00E+00	2.20E-11	2.80E-06
1,4-Dichlorobenzen	7.02E-03	0.00E+00	6.93E-07	1.32E-06	1.79E-08	6.06E-08	6.29E-09	2.10E-06	7.02E-03
Ethyl benzene	5.60E-02	1.60E-06	0.00E+00	0.00E+00	1.06E-09	3.41E-07	8.07E-12	3.42E-07	5.60E-02
Fluoranthene	2.62E-02	0.00E+00	5.31E-05	9.69E-04	1.06E-04	2.11E-05	4.82E-05	1.20E-03	2.74E-02
Flourene	1.01E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.47E-08	0.00E+00	2.47E-08	1.01E-03
2-Methylnaphthaler	1.23E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.35E-11	0.00E+00	5.35E-11	1.23E-02
Methylene Chloride	7.56E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.88E-09	0.00E+00	2.88E-09	7.56E-03
Naphthalene	1.32E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	1.41E-07	0.00E+00	1.41E-07	1.32E-02

Phenanthrene	2.55E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	9.83E-08	0.00E+00	9.83E-08	2.55E-03
Pyrene	2.38E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.86E-07	0.00E+00	2.86E-07	2.38E-03
Toluene	8.12E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.43E-07	0.00E+00	2.43E-07	8.12E-02
Xylenes	6.33E-01	9.45E-06	1.19E-06	1.73E-06	2.47E-08	3.86E-06	8.68E-09	6.81E-06	6.33E-01
Pesticides/PCBs									
Aldrin	4.53E-04	0.00E+00	1.42E-07	1.55E-07	1.31E-09	2.78E-09	9.12E-10	3.02E-07	4.53E-04
Aroclor 1242	7.28E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.37E-06	0.00E+00	2.37E-06	7.28E-03
Aroclor 1254	7.56E-03	0.00E+00	2.77E-06	2.31E-04	1.11E-04	1.66E-05	3.80E-05	3.99E-04	7.96E-03
4,4'-DDD	6.33E-05	0.00E+00	1.17E-08	9.77E-07	4.70E-07	8.77E-08	1.77E-07	1.72E-06	6.50E-05
4,4'-DDE	9.52E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	2.02E-09	0.00E+00	2.02E-09	9.52E-06
4,4'-DDT	2.02E-04	0.00E+00	8.44E-09	1.25E-06	1.06E-06	2.59E-07	3.72E-07	2.95E-06	2.05E-04
Dieldrin	1.18E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.23E-09	0.00E+00	5.23E-09	1.18E-04
Endosulfan I	4.76E-06	0.00E+00	0.00E+00	0.00E+00	0.00E+00	5.11E-11	0.00E+00	5.11E-11	4.76E-06
Endrin	2.60E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	4.80E-09	0.00E+00	4.80E-09	2.60E-05
Beta BHC	4.76E-05	0.00E+00	0.00E+00	0.00E+00	0.00E+00	6.80E-10	0.00E+00	6.80E-10	4.76E-05

Table A.7-17 Exposure Rates for American Woodcock (mg/kg/day)

Chemical	Environmental Media		Biota	Total
	Soils	Water	Invertebrates	Exposure
Inorganics				
Arsenic	7.13E-01	0.00E+00	3.01E+00	3.72E+00
Beryllium	2.69E-02	0.00E+00	3.57E+00	3.59E+00
Cadmium	7.43E-02	0.00E+00	3.93E+01	3.94E+01
Chromium	5.26E-01	0.00E+00	2.56E+01	2.61E+01
Copper	7.40E+00	0.00E+00	7.62E+01	8.36E+01
Lead	2.18E+01	0.00E+00	1.06E+03	1.08E+03
Mercury	2.90E-03	0.00E+00	8.28E-01	8.31E-01
Nickel	1.27E+01	0.00E+00	5.92E+01	7.19E+01
Selenium	7.93E-01	0.00E+00	3.03E+00	3.82E+00
Thallium	2.04E-03	0.00E+00	0.00E+00	2.04E-03
Uranium	9.20E+00	0.00E+00	1.79E+02	1.88E+02
Zinc	4.07E+00	0.00E+00	9.29E+02	9.33E+02
Organics				
Acetone	4.25E-04	0.00E+00	1.95E-03	2.38E-03
Bis(2-ethylhexyl)phthalate	7.57E-01	0.00E+00	5.76E+00	6.52E+00
2,4-Dimethylphenol	0.00E+00	1.64E-04	0.00E+00	1.64E-04
Di-n-octylphthalate	1.21E-01	0.00E+00	1.45E+00	1.57E+00
1,4-Dichlorobenzene	1.34E-04	0.00E+00	8.30E-04	9.64E-04
Ethyl benzene	0.00E+00	4.80E-06	0.00E+00	4.80E-06
Fluoranthene	8.21E-02	0.00E+00	6.14E-01	6.96E-01
Xylenes	1.79E-04	2.84E-05	7.09E-04	9.16E-04
Pesticides/PCBs				
Aldrin	1.64E-05	0.00E+00	9.81E-05	1.15E-04
Aroclor 1254	1.73E-02	0.00E+00	1.46E-01	1.64E-01
4,4'-DDD	7.34E-05	0.00E+00	6.20E-04	6.93E-04

Table A.7-18 Exposure Rates for Red-tailed Hawk (mg/kg/day)

Chemical	Environmental Media	Biota				Total Exposure
	Water	White-footed Mouse	Cottontail Rabbit	American Robin	Total	
Inorganics						
Antimony	0.00E+00	0.00E+00	2.73E-11	0.00E+00	2.73E-11	2.73E-11
Arsenic	0.00E+00	6.23E-05	4.23E-04	1.45E-05	5.00E-04	5.00E-04
Beryllium	0.00E+00	5.34E-12	1.71E-10	1.85E-12	1.78E-10	1.78E-10
Cadmium	0.00E+00	5.54E-02	2.75E-01	1.77E-02	3.49E-01	3.49E-01
Chromium	0.00E+00	4.04E-03	1.13E-03	1.16E-03	6.34E-03	6.34E-03
Copper	0.00E+00	2.22E-01	2.00E+00	5.61E-02	2.28E+00	2.28E+00
Lead	0.00E+00	5.65E-02	1.19E-01	1.85E-02	1.95E-01	1.95E-01
Mercury	0.00E+00	1.84E-04	7.87E-05	5.38E-05	3.17E-04	3.17E-04
Nickel	0.00E+00	8.12E-03	3.93E-02	1.73E-03	4.92E-02	4.92E-02
Selenium	0.00E+00	5.23E-02	5.62E-01	1.39E-02	6.28E-01	6.28E-01
Thallium	0.00E+00	4.98E-08	2.62E-07	2.94E-09	3.15E-07	3.15E-07
Uranium	0.00E+00	3.47E-10	1.22E-08	1.22E-07	1.34E-07	1.34E-07
Zinc	0.00E+00	5.38E-01	7.49E-01	1.70E-01	1.46E+00	1.46E+00
Organics						
Acetone	0.00E+00	4.59E-10	7.10E-09	2.57E-09	1.01E-08	1.01E-08
Bis(2-ethylhexyl)phthalate	0.00E+00	1.10E-04	1.53E-04	1.82E-04	4.45E-04	4.45E-04
Butyl benzyl phthalate	0.00E+00	0.00E+00	2.25E-05	0.00E+00	2.25E-05	2.25E-05
Chlorobenzene	0.00E+00	0.00E+00	1.58E-08	0.00E+00	1.58E-08	1.58E-08
Di-n-butylphthalate	0.00E+00	0.00E+00	1.91E-06	0.00E+00	1.91E-06	1.91E-06
2,4-Dimethylphenol	1.58E-05	1.07E-09	2.14E-09	3.54E-11	3.24E-09	1.58E-05
Di-n-octylphthalate	0.00E+00	9.34E-03	7.14E-03	7.39E-03	2.39E-02	2.39E-02
1,2-Dichlorobenzene	0.00E+00	0.00E+00	1.44E-11	0.00E+00	1.44E-11	1.44E-11
1,4-Dichlorobenzene	0.00E+00	1.60E-09	3.97E-08	2.14E-09	4.34E-08	4.34E-08
Ethyl benzene	4.64E-07	9.49E-11	2.23E-07	2.75E-12	2.23E-07	6.88E-07
Fluoranthene	0.00E+00	9.51E-06	1.38E-05	1.64E-05	3.97E-05	3.97E-05
Flourene	0.00E+00	0.00E+00	1.62E-08	0.00E+00	1.62E-08	1.62E-08
2-Methylnaphthalene	0.00E+00	0.00E+00	3.50E-11	0.00E+00	3.50E-11	3.50E-11
Methylene Chloride	0.00E+00	0.00E+00	1.89E-09	0.00E+00	1.89E-09	1.89E-09
Naphthalene	0.00E+00	0.00E+00	9.26E-08	0.00E+00	9.26E-08	9.26E-08
Phenanthrene	0.00E+00	0.00E+00	6.44E-08	0.00E+00	6.44E-08	6.44E-08
Pyrene	0.00E+00	0.00E+00	1.87E-07	0.00E+00	1.87E-07	1.87E-07
Toluene	0.00E+00	0.00E+00	1.59E-07	0.00E+00	1.59E-07	1.59E-07
Xylenes	2.74E-06	2.21E-09	2.53E-06	2.95E-09	2.53E-06	5.28E-06
Pesticides/PCBs						
Aldrin	0.00E+00	1.17E-10	1.82E-09	3.10E-10	2.25E-09	2.25E-09
Aroclor 1242	0.00E+00	0.00E+00	1.55E-06	0.00E+00	1.55E-06	1.55E-06
Aroclor 1254	0.00E+00	9.92E-06	1.09E-05	1.29E-05	3.37E-05	3.37E-05
4,4'-DDD	0.00E+00	4.20E-08	5.74E-08	6.01E-08	1.60E-07	1.60E-07
4,4'-DDE	0.00E+00	0.00E+00	1.32E-09	0.00E+00	1.32E-09	1.32E-09
4,4'-DDT	0.00E+00	9.48E-08	1.69E-07	1.26E-07	3.91E-07	3.91E-07
Dieldrin	0.00E+00	0.00E+00	3.43E-09	0.00E+00	3.43E-09	3.43E-09
Endosulfan I	0.00E+00	0.00E+00	3.35E-11	0.00E+00	3.35E-11	3.35E-11
Endrin	0.00E+00	0.00E+00	3.14E-09	0.00E+00	3.14E-09	3.14E-09
Beta BHC	0.00E+00	0.00E+00	4.45E-10	0.00E+00	4.45E-10	4.45E-10

TABLE A.7-19
BENCHMARK VALUES FOR ECOLOGICAL RECEPTORS [1]

	Plants (mg/kg)	Invertebrates (mg/kg)	American Robin (mg/kg/day)	American Woodcock (mg/kg/day)	Red-tailed Hawk (mg/kg/day)	White-footed Mouse (mg/kg/day)	Cottontail Rabbit (mg/kg/day)	Red Fox (mg/kg/day)
Inorganics								
Antimony	5.00E+00	ND [8]	ND	ND	ND	1.35E-01	5.00E-02	3.60E-02
Arsenic	1.00E+01	6.00E+01	5.10E+00	5.10E+00	5.10E+00	1.36E-01	5.00E-02	3.60E-02
Beryllium	1.00E+01	ND	ND	ND	ND	1.32E+00	4.90E-01	3.50E-01
Cadmium	3.00E+00	2.00E+01	1.45E+00	1.45E+00	1.45E+00	1.93E+00	7.09E-01	5.09E-01
Chromium	1.00E+00	4.00E-01	1.00E+00	1.00E+00	1.00E+00	5.47E+03	2.01E+03	1.45E+03
Copper	1.00E+02	5.00E+01	4.70E+01	4.70E+01	4.70E+01	3.04E+01	1.12E+01	8.00E+00
Cyanide	ND	ND	ND	ND	ND	1.29E+02	4.74E+01	3.41E+01
Lead	5.00E+01	5.00E+02	3.85E+00	3.85E+00	3.85E+00	1.60E+01	5.88E+00	4.22E+00
Mercury	3.00E-01	1.00E-01	4.50E-01	4.50E-01	4.50E-01	2.60E+00	9.60E-01	6.90E-01
Nickel	3.00E+01	2.00E+02	7.74E+01	7.74E+01	7.74E+01	7.99E+01	2.94E+01	2.11E+01
Selenium	1.00E+00	7.00E+01	5.00E-02	5.00E-02	5.00E-02	3.99E-01	1.47E-01	1.06E-01
Thallium	1.00E+00	ND	ND	ND	ND	1.50E-02	5.00E-03	4.00E-03
Uranium	5.00E+00	ND	1.60E+01	1.60E+01	1.60E+01	3.26E+00	1.20E+00	8.62E+00
Zinc	5.00E+01	2.00E+02	1.45E+01	1.45E+01	1.45E+01	3.20E+02	1.18E+02	8.45E+01
Organics								
Acetone	ND	ND	ND	ND	ND	2.00E+01	7.30E+00	5.30E+00
Bis(2-ethylhexyl)phthalate	ND	2.00E+02 [2]	1.10E+00	1.10E+00	1.10E+00	1.98E+01	7.30E+00	5.20E+00
Butyl benzyl phthalate	*ND*	*2.00E+02* [2]	*ND*	*ND*	*ND*	*4.00E+02*	*1.05E+02*	*6.79E+01*
Chlorobenzene	ND	4.00E+01	ND	ND	ND	1.08E+01	4.00E-01	3.00E-01
Di-n-butylphthalate	2.00E+02	2.00E+02 [2]	1.10E-01	1.10E-01	1.10E-01	5.94E+02	2.19E+02	1.57E+02
2,4-Dimethylphenol	ND	ND	ND	ND	ND	5.54E+00	1.46E+00	9.41E-01
Di-n-octylphthalate	2.00E+02 [4]	2.00E+02 [2]	ND	ND	ND	ND	ND	ND
1,2-Dichlorobenzene	ND	2.00E+01	ND	ND	ND	2.15E+02	5.70E+01	3.70E+01
1,4-Dichlorobenzene	ND	2.00E+01	ND	ND	ND	2.37E+02	7.10E+01	4.60E+01
Ethyl benzene	ND	ND	ND	ND	ND	2.44E+02	6.44E+01	4.14E+01
Fluoranthene	ND	3.00E+01 [5]	ND	ND	ND	1.08E+00 [6]	4.00E-01 [6]	2.90E-01 [6]

Fluorene	ND	3.00E+01 [5]	ND	ND	ND	1.08E+00 [6]	4.00E-01 [6]	2.90E-01 [6]
2-Methylnaphthalene	ND	3.00E+01 [5]	ND	ND	ND	1.08E+00 [6]	4.00E-01 [6]	2.90E-01 [6]
Methylene Chloride	ND	ND	ND	ND	ND	1.17E+01	4.30E+00	3.10E+00
Naphthalene	ND	3.00E+01 [5]	ND	ND	ND	1.08E+00 [6]	4.00E-01 [6]	2.90E-01 [6]
Phenanthrene	ND	3.00E+01 [5]	ND	ND	ND	1.08E+00 [6]	4.00E-01 [6]	2.90E-01 [6]
Pyrene	ND	3.00E+01 [5]	ND	ND	ND	1.08E+00 [6]	4.00E-01 [6]	2.90E-01 [6]
Toluene	2.00E+02	ND	ND	ND	ND	2.81E+01	1.03E+01	7.40E+00
Xylenes	ND	ND	ND	ND	ND	2.27E+00	8.35E-01	6.00E-01
Pesticides/PCBs								
Aldrin	ND	2.20E+00 [3]	ND	ND	ND	3.99E-01	1.47E-01	1.06E-01
Aroclor 1242	4.00E+01	ND	4.10E-01	4.10E-01	4.10E-01	1.79E-01	6.60E-02	4.70E-02
Aroclor 1254	4.00E+01	ND	1.80E-01	1.80E-01	1.80E-01	6.10E-02	2.20E-02	9.60E-02
4,4'-DDD	ND	2.00E+03 [7]	3.00E-03	3.00E-03	3.00E-03	1.60E+00	5.90E-01	4.20E-01
4,4'-DDE	ND	2.00E+03 [7]	3.00E-03	3.00E-03	3.00E-03	1.60E+00	5.90E-01	4.20E-01
4,4'-DDT	ND	2.00E+03 [3]	3.00E-03	3.00E-03	3.00E-03	1.60E+00	5.90E-01	4.20E-01
Dieldrin	ND	3.00E+01 [3]	7.70E-02	7.70E-02	7.70E-02	4.00E-02	1.50E-02	1.10E-02
Endosulfan I	ND	1.00E+00 [3]	1.00E+01	1.00E+01	1.00E+01	3.00E-01	1.10E-01	8.00E-02
Endrin	ND	ND	1.00E-02	1.00E-02	1.00E-02	9.90E-02	3.70E-02	2.60E-02
Beta BHC	ND	ND	ND	ND	ND	8.00E-01	2.90E-01	2.10E-01

[1] Benchmark values from ORNL 1996, unless otherwise noted.

[2] The value for dimethylphthalate was used for all phthalates for earthworms.

[3] Value derived from published literature.

[4] Values for di=n=butylphthalate was used for di-n-octylphalate.

[5] The toxicity of flourene was used for all PAH for invertebrates

[6] The value for benzo(a)pyrene was used for all PAH in mammals

[7] Benchmark for DDT used for DDD and DDE.

[8] ND = No data available.

TABLE A.7-20
DERIVATION OF BENCHMARK VALUES FOR EARTHWORMS

Chemical	Toxicity Concentration (mg/kg)	Type of Toxicity Value	Uncertainty Factor	Benchmark Concentration (mg/kg)	Reference
Aldrin	10.79	14-day LC_{50}	5	2.2	Hans et al. 1990
4,4'-DDT	2000	NOEC	1	2000	Edwards and Thompson 1973
Dieldrin	30	NOEC	1	2.2	Venter and Reinecke 1985
Endosulfan I	5.01	24-day LC_{50}	5	1	Hans et al. 1990

NOEC - No observable effect concentration.

LC_{50} - The concentration of contaminant that is lethal to 50 percent of the exposed population within the specified time period.

TABLE A.7-21
DERIVATION OF BENCHMARK VALUES FOR TERRESTRIAL MAMMALS

Chemical	Toxicity Value (mg/kg/day)	Type of Toxicity Value	Uncertainty Factor	Test Animal	Benchmark Values (mg/kg/day) White-footed Mouse	Cottontail Rabbit	Red Fox	Reference
Butyl benzyl phthalate	470	Subchronic NOAEL	10	Rat	4.00E+02	1.05E+02	6.79E+01	EPA 1977
Chlorobenzene	19	Subchronic NOAEL	10	Dog	NA [1]	4.00E-01	3.00E-01	ATSDR 1990
Chlorobenzene	43	Chronic NOAEL	1	Rat	1.08E+01	NA	NA	ATSDR 1990
2,4-Dimethylphenol	50	Subchronic NOAEL	10	Mouse	5.54E+00	1.46E+00	9.41E-01	EPA 1977
1,2-Dichlorobenzene	85.7	Chronic NOAEL	1	Rat	NA	5.70E+01	3.70E+01	EPA 1997e
1,2-Dichlorobenzene	85.7	Chronic NOAEL	1	Mouse	2.15E+02	NA	NA	EPA 1997e
1,4-Dichlorobenzene	214	Chronic NOAEL	1	Mouse	2.37E+02	NA	NA	ATSDR 1993
1,4-Dichlorobenzene	107	Chronic NOAEL	1	Rat	NA	7.10E+01	4.60E+01	ATSDR 1993
Ethyl benzene	97.1	Chronic NOAEL	1	Rat	2.44E+02	6.44E+01	4.14E+01	EPA 1977

NOAEL - No observed adverse effect level

Body weights (kg) - Mouse= 0.03; rat=0.35; and dog=12.7 (Will and Suter, 1996)

[1] NA = Not applicable.

TABLE A.7-22
SUMMARY OF RISK FINDINGS FOR PLANTS AND INVERTEBRATES. AREA 1

	Plants			Invertebrates		
Chemical	Maximum Concentration (mg/kg)	Benchmark Concentration (mg/kg)	Hazard Quotient (HQ)	Maximum Concentration (mg/kg)	Benchmark Concentration (mg/kg)	Hazard Quotient (HQ)
Inorganics						
Arsenic	2.20E+02	1.00E+01	2.20E+01	2.20E+02	6.00E+01	3.67E+00
Beryllium	3.30E+00	1.00E+01	3.30E-01	3.30E+00	ND	ND
Cadmium	7.90E+00	3.00E+00	2.63E+00	7.90E+00	2.00E+01	3.95E-01
Chromium	3.10E+01	1.00E+00	3.10E+01	3.10E+01	4.00E-01	7.75E+01
Copper	2.30E+03	1.00E+02	2.30E+01	2.30E+03	5.00E+01	4.60E+01
Lead	3.20E+02	5.00E+01	6.40E+00	3.20E+02	5.00E+02	6.40E-01
Mercury	1.70E-01	3.00E-01	5.67E-01	1.70E-01	1.00E-01	1.70E+00
Nickel	3.60E+03	3.00E+01	1.20E+02	3.60E+03	2.00E+02	1.80E+01
Selenium	2.50E+02	1.00E+00	2.50E+02	2.50E+02	7.00E+01	3.57E+00
Thallium	1.20E+00	1.00E+00	1.20E+00	1.20E+00	ND	ND
Uranium	4.38E+02	5.00E+00	8.75E+01	4.38E+02	ND	ND
Zinc	1.20E+02	5.00E+01	2.40E+00	1.20E+02	2.00E+02	6.00E-01
Organics						
Acetone	3.40E-02	ND	ND	3.40E-02	ND	ND
Bis(2-ethylhexyl)phthalate	7.80E+00	ND	ND	7.80E+00	2.00E+02	3.90E-02
Di-n-octylphthalate	3.00E+00	2.00E+02	1.50E-02	3.00E+00	2.00E+02	1.50E-02
1,4-Dichlorobenzene	4.20E-02	ND	ND	4.20E-02	2.00E+01	2.10E-03
Xylenes	3.70E-02	ND	ND	3.70E-02	ND	ND
Pesticides/PCBs						
Aroclor 1254	1.10E+00	4.00E+01	2.75E-02	1.10E+00	ND	ND
Totals			5.47E+02			1.52E+02

TABLE A.7-23
SUMMARY OF RISK FINDINGS FOR WILDLIFE WITH SMALL HOME RANGES, AREA 1

	White-footed Mouse			Cottontail Rabbit			American Robin		
Chemical	Intake (mg/kg/day)	Benchmark Value (mg/kg/day)	Hazard Quotient (HQ)	Intake (mg/kg/day)	Benchmark Value (mg/kg/day)	Hazard Quotient (HQ)	Intake (mg/kg/day)	Benchmark Value (mg/kg/day)	Hazard Quotient (HQ)
Inorganics									
Antimony	NA [1]	1.35E-01	NA	3.31E-02	5.00E-02	6.62E-01	NA	ND [2]	NA
Arsenic	7.00E+01	1.36E-01	5.15E+02	3.05E+01	5.00E-02	6.10E+02	4.64E+01	5.10E+00	9.11E+00
Beryllium	1.52E-02	1.32E+00	1.16E-02	2.64E-02	4.90E-01	5.38E-02	1.03E-02	ND	ND
Cadmium	1.17E+02	1.93E+00	6.06E+01	3.10E+01	7.09E-01	4.37E+01	7.07E+01	1.45E+00	4.88E+01
Chromium	2.35E+01	5.47E+03	4.31E-03	1.96E+00	2.01E+03	9.73E-04	1.19E+01	1.00E+00	1.19E+01
Copper	3.90E+03	3.04E+01	1.28E+02	2.26E+03	1.12E+01	2.02E+02	2.82E+03	4.70E+01	6.00E+01
Cyanide	NA	1.29E+02	NA	7.59E-03	4.74E+01	1.60E-04	NA	ND	NA
Lead	2.26E+02	1.60E+01	1.41E+01	2.76E+01	5.88E+00	4.70E+00	1.22E+02	3.85E+00	3.18E+01
Mercury	8.13E-01	2.60E+00	3.13E-01	1.78E-02	9.60E-01	1.86E-02	4.17E-01	4.50E-01	9.28E-01
Nickel	1.60E+02	7.99E+01	2.00E+00	4.84E+01	2.94E+01	1.64E+00	9.09E+01	7.74E+01	1.17E+00
Selenium	1.03E+03	3.99E-01	2.59E+03	7.18E+02	1.47E-01	4.88E+03	7.93E+02	5.00E-02	1.59E+04
Thallium	1.88E-02	1.50E-02	1.25E+00	8.80E-03	5.00E-03	1.76E+00	1.01E-02	ND	ND
Uranium	1.55E+00	3.26E+00	4.75E-01	3.42E+00	1.20E+00	2.85E+00	1.04E+00	1.60E+01	6.50E-02
Zinc	4.67E+02	3.20E+02	1.46E+00	3.55E+01	1.18E+02	3.02E-01	1.04E+00	1.45E+01	7.17E-02
Organics									
Acetone	5.76E-02	2.00E+01	2.88E-03	1.26E-01	7.30E+00	1.72E-02	4.41E-02	ND	ND
Bis(2-ethylhexyl)phthalate	9.03E-01	1.98E+01	4.56E-02	1.66E-01	7.30E+00	2.27E-02	4.62E-01	1.10E+00	4.20E-01
Butyl benzyl phthalate	NA	4.00E+02	NA	1.24E+00	1.05E+02	1.18E-02	NA	ND	NA
Chlorobenzene	NA	1.58E+01	NA	1.72E-02	4.17E+00	4.13E-03	NA	ND	NA
Di-n-butylphthalate	NA	5.94E+02	NA	6.90E-02	2.19E+02	3.15E-04	NA	1.10E-01	NA
2,4-Dimethylphenol	*2.25E-02*	*5.54E+00*	*4.06E-03*	4.00E-03	1.46E+00	2.74E-03	8.11E-04	ND	ND
Di-n-octylphthalate	5.45E-01	ND	ND	2.55E-02	ND	ND	2.77E-01	ND	ND
1,2-Dichlorobenzene	NA	2.16E+02	NA	6.90E-06	5.68E+01	1.21E-07	NA	ND	NA
1,4-Dichlorobenzene	4.52E-03	4.73E+01	9.55E-05	1.76E-02	1.25E+01	1.41E-03	2.45E-03	ND	ND
Ethyl benzene	6.60E-04	2.44E+02	2.70E-06	1.38E-01	6.44E+01	2.14E-03	2.38E-05	ND	ND
Fluoranthene	NA	1.08E+00	NA	5.86E-03	4.00E-01	1.47E-02	NA	ND	NA
Fluorene	NA	1.08E+00	NA	2.48E-03	4.00E-01	6.21E-03	NA	ND	NA
2-Methylnaphthalene	NA	1.08E+00	NA	3.03E-02	4.00E-01	7.59E-02	NA	ND	NA
Methylene Chloride	NA	1.17E+01	NA	1.86E-02	4.30E+00	4.33E-03	NA	ND	NA
Naphthalene	NA	1.08E+00	NA	3.24E-02	4.00E-01	8.10E-02	NA	ND	NA
Phenanthrene	NA	1.08E+00	NA	6.28E-03	4.00E-01	1.57E-02	NA	ND	NA
Pyrene	NA	1.08E+00	NA	5.86E-03	4.00E-01	1.47E-02	NA	ND	NA

Toluene	NA	2.81E+01	NA	2.00E-01	1.03E+01	1.94E-02	NA	ND	NA
Xylenes	7.94E-03	2.27E+00	3.50E-03	1.56E+00	8.35E-01	1.87E+00	2.37E-03	ND	ND
Pesticides/PCBs									
Aldrin	NA	3.99E-01	NA	1.10E-03	1.47E-01	7.51E-03	NA	ND	NA
Aroclor 1242	NA	1.79E-01	NA	1.79E-02	6.60E-02	2.72E-01	NA	4.10E-01	NA
Aroclor 1254	1.40E-01	6.10E-02	2.29E+00	7.90E-03	2.20E-02	3.59E-01	7.11E-02	1.80E-01	3.95E-01
4,4'-DDD	NA	1.60E+00	NA	1.03E-04	5.90E-01	1.75E-04	NA	3.00E-03	NA
4,4'-DDE	NA	1.60E+00	NA	2.34E-05	5.90E-01	3.97E-05	NA	3.00E-03	NA
4,4'-DDT	NA	1.60E+00	NA	4.34E-04	5.90E-01	7.36E-04	NA	3.00E-03	NA
Dieldrin	NA	4.00E-02	NA	2.90E-04	1.50E-02	1.93E-02	NA	7.70E-02	NA
Endosulfan I	NA	3.00E-01	NA	1.17E-05	1.10E-01	1.07E-04	NA	1.00E+01	NA
Endrin	NA	9.90E-02	NA	6.41E-05	3.70E-02	1.73E-03	NA	1.00E-02	NA
Beta BHC	NA	8.00E-01	NA	1.17E-04	2.90E-01	4.04E-04	NA	ND	NA
Totals:			3.32E+03			5.75E+03			1.60E+04

[1] NA = Not applicable.

[2] ND = Insufficient data to calculate value.

TABLE A.7-24
SUMMARY OF RISK FINDINGS FOR THE PLANTS AND INVERTEBRATES, AREA 2

	Plants			Invertebrates		
Chemical	95% CI Concentration (mg/kg)	Benchmark Concentration (mg/kg)	Hazard Quotient (HQ)	95% CI Concentration (mg/kg)	Benchmark Concentration (mg/kg)	Hazard Quotient (HQ)
Inorganics						
Arsenic	3.50E+01	1.00E+01	3.50E+00	3.50E+01	6.00E+01	5.83E-01
Beryllium	2.20E+00	1.00E+01	2.20E-01	2.20E+00	ND	ND
Cadmium	6.30E+00	3.00E+00	2.10E+00	6.30E+00	2.00E+01	3.15E-01
Chromium	4.90E+01	1.00E+00	4.90E+01	4.90E+01	4.00E-01	1.23E+02
Copper	3.60E+02	1.00E+02	3.60E+00	3.60E+02	5.00E+01	7.20E+00
Lead	2.20E+03	5.00E+01	4.40E+01	2.20E+03	5.00E+02	4.40E+00
Mercury	2.70E-01	3.00E-01	9.00E-01	2.70E-01	1.00E-01	2.70E+00
Nickel	6.80E+02	3.00E+01	2.27E+01	6.80E+02	2.00E+02	3.40E+00
Selenium	3.80E+01	1.00E+00	3.80E+01	3.80E+01	7.00E+01	5.43E-01
Uranium	8.75E+02	5.00E+00	1.75E+02	8.75E+02	ND	ND
Zinc	4.00E+02	5.00E+01	8.00E+00	4.00E+02	2.00E+02	2.00E+00
Organics						
Acetone	3.80E-02	ND	ND	3.80E-02	ND	ND
Bis(2-ethylhexyl)phthalate	7.70E+01	ND	ND	7.70E+01	2.00E+02	3.85E-01
Di-n-octylphthalate	1.20E+01	2.00E+02	6.00E-02	1.20E+01	2.00E+02	6.00E-02
1,4-Dichlorobenzene	6.50E-03	ND	ND	6.50E-03	2.00E+01	3.25E-04
Fluoranthene	8.50E+00	ND	ND	8.50E+00	3.00E+01	2.83E-01
Xylenes	1.20E-02	ND	ND	1.20E-02	ND	ND
Pesticides/PCBs						
Aldrin	1.70E-03	ND	ND	1.70E-03	2.20E+00	7.73E-04
Aroclor 1254	1.60E+00	4.00E+01	4.00E-02	1.60E+00	ND	ND
4,4'-DDD	7.60E-03	ND	ND	7.60E-03	2.00E+03	3.80E-06
4,4'-DDT	9.30E-03	ND	ND	9.30E-03	2.00E+03	4.65E-06
Totals:			3.47E+02			1.44E+02

TABLE A.7-25
SUMMARY OF RISK FINDINGS FOR WILDLIFE WITH SMALL HOME RANGES, AREA 2

	White-footed Mouse			Cottontail Rabbit			American Robin		
Chemical	Intake (mg/kg/day)	Benchmark Value (mg/kg/day)	Hazard Quotient (HQ)	Intake (mg/kg/day)	Benchmark Value (mg/kg/day)	Hazard Quotient (HQ)	Intake (mg/kg/day)	Benchmark Value (mg/kg/day)	Hazard Quotient (HQ)
Inorganics									
Arsenic	1.11E+01	1.36E-01	8.19E+01	8.80E+00	5.00E-02	1.76E+02	4.19E+01	5.10E+00	8.21E+00
Beryllium	1.02E-02	1.32E+00	7.70E-03	3.18E-02	4.90E-01	6.50E-02	3.89E-02	ND [1]	ND
Cadmium	9.31E+01	1.93E+00	4.83E+01	4.47E+01	7.09E-01	6.31E+01	3.20E+02	1.45E+00	2.20E+02
Chromium	3.72E+01	5.47E+03	6.81E-03	6.85E-01	2.01E+03	3.41E-04	1.07E+02	1.00E+00	1.07E+02
Copper	6.10E+02	3.04E+01	2.01E+01	6.42E+02	1.12E+01	5.73E+01	2.50E+03	4.70E+01	5.32E+01
Lead	1.56E+03	1.60E+01	9.74E+01	2.95E+02	5.88E+00	5.01E+01	4.76E+03	3.85E+00	1.24E+03
Mercury	1.29E+00	2.60E+00	4.97E-01	5.14E-02	9.60E-01	5.35E-02	3.76E+00	4.50E-01	8.35E+00
Nickel	3.01E+01	7.99E+01	3.77E-01	1.66E+01	2.94E+01	5.63E-01	9.74E+01	7.74E+01	1.26E+00
Selenium	1.57E+02	3.99E-01	3.94E+02	1.98E+02	1.47E-01	1.35E+03	6.84E+02	5.00E-02	1.37E+04
Uranium	1.09E+00	3.26E+00	3.34E-01	1.24E+01	1.20E+00	1.03E+01	4.14E+00	1.60E+01	2.59E-01
Zinc	1.09E+00	3.20E+02	3.41E-03	1.24E+01	1.18E+02	1.05E-01	4.14E+00	1.45E+01	2.86E-01
Organics									
Acetone	6.44E-02	2.00E+01	3.22E-03	8.05E-02	7.30E+00	1.10E-02	2.79E-01	ND	ND
Bis(2-ethylhexyl)phthalate	8.91E+00	1.98E+01	4.50E-01	1.10E+00	7.30E+00	1.50E-01	2.59E+01	1.10E+00	2.35E+01
Di-n-octylphthalate	2.18E+00	ND	ND	1.50E-01	ND	ND	6.27E+00	ND	ND
1,4-Dichlorobenzene	6.99E-04	4.73E+01	1.48E-05	1.90E-04	1.25E+01	1.53E-05	2.15E-03	ND	ND
Fluoranthene	9.70E-01	1.08E+00	8.98E-01	1.24E-01	4.00E-01	3.10E-01	2.82E+00	ND	ND
Xylenes	1.31E-03	2.27E+00	5.78E-04	4.10E-04	8.35E-01	4.90E-04	4.09E-03	ND	ND
Pesticides/PCBs									
Aldrin	1.91E-04	3.99E-01	4.79E-04	6.92E-05	1.47E-01	4.71E-04	6.08E-04	ND	ND
Aroclor 1254	2.03E-01	6.10E-02	3.33E+00	2.08E-02	2.20E-02	9.47E-01	5.87E-01	1.80E-01	3.26E+00
4,4'-DDD	9.65E-04	1.60E+00	6.03E-04	9.90E-05	5.90E-01	1.68E-04	2.79E-03	3.00E-03	9.29E-01
4,4'-DDT	1.23E-03	1.60E+00	7.71E-04	1.19E-04	5.90E-01	2.02E-04	3.56E-03	3.00E-03	1.19E+00
Totals:			6.47E+02			1.70E+03			1.53E+04

[1] ND = Insufficient data to calculate value.

TABLE A.7-26
SUMMARY OF RISK FINDINGS FOR WILDLIFE WITH LARGE HOME RANGES, OPERABLE UNIT 1

	Red-tailed Fox			American Woodcock			Red-tailed Hawk		
Chemical	Intake (mg/kg/day)	Benchmark Value (mg/kg/day)	Hazard Quotient (HQ)	Intake (mg/kg/day)	Benchmark Value (mg/kg/day)	Hazard Quotient (HQ)	Intake (mg/kg/day)	Benchmark Value (mg/kg/day)	Hazard Quotient (HQ)
Inorganics									
Antimony	1.34E-02	3.60E-02	3.73E-01	NA [1]	ND [2]	NA	2.73E-11	ND	ND
Arsenic	8.08E-01	3.60E-02	2.24E+01	3.72E+00	5.10E+00	7.29E-01	4.62E-04	5.10E+00	9.06E-05
Beryllium	1.54E-02	3.50E-01	4.41E-02	3.59E+00	ND	ND	1.77E-10	ND	ND
Cadmium	3.57E+01	5.09E-01	7.01E+01	3.94E+01	1.45E+00	2.72E+01	3.12E-01	1.45E+00	2.15E-01
Chromium	1.10E+00	1.45E+03	7.60E-04	2.61E+01	1.00E+00	2.61E+01	3.75E-03	1.00E+00	3.75E-03
Copper	2.26E+01	8.00E+00	2.83E+00	8.36E+01	4.70E+01	1.78E+00	2.14E+00	4.70E+01	4.56E-02
Cyanide	3.08E-03	3.41E+01	9.03E-05	NA	ND	NA	NA	ND	NA
Lead	2.88E+01	4.22E+00	6.83E+00	1.08E+03	3.85E+00	2.80E+02	1.57E-01	3.85E+00	4.08E-02
Mercury	8.73E-03	6.90E-01	1.26E-02	8.31E-01	4.50E-01	1.85E+00	1.98E-04	4.50E-01	4.39E-04
Nickel	1.24E+01	2.11E+01	5.86E-01	7.19E+01	7.74E+01	9.29E-01	4.46E-02	7.74E+01	5.76E-04
Selenium	4.98E+00	1.06E-01	4.70E+01	3.82E+00	5.00E-02	7.65E+01	5.95E-01	5.00E-02	1.19E+01
Thallium	3.36E-03	4.00E-03	8.41E-01	2.04E-03	ND	ND	2.94E-07	ND	ND
Uranium	9.52E-01	8.62E+00	1.10E-01	1.88E+02	1.60E+01	1.18E+01	1.13E-07	1.60E+01	7.09E-09
Zinc	9.76E+01	8.45E+01	1.16E+00	1.88E+02	1.45E+01	1.30E+01	1.13E-07	1.45E+01	7.83E-09
Organics									
Acetone	3.56E-02	5.30E+00	6.72E-03	2.38E-03	ND	ND	1.01E-08	ND	ND
Bis(2-ethylhexyl)phthalate	3.03E-01	5.20E+00	5.82E-02	6.52E+00	1.10E+00	5.92E+00	4.45E-04	1.10E+00	4.05E-04
Butyl benzyl phthalate	5.04E-01	6.79E+01	7.43E-03	NA	ND	NA	2.25E-05	ND	ND
Chlorobenzene	7.00E-03	2.69E+00	2.61E-03	NA	ND	NA	1.58E-08	ND	ND
Di-n-butylphthalate	2.80E-02	1.57E+02	1.78E-04	NA	1.10E-01	NA	1.91E-06	1.10E-01	1.74E-05
2,4-Dimethylphenol	5.46E-05	9.41E-01	5.80E-05	1.64E-04	ND	ND	1.58E-05	ND	ND
Di-n-octylphthalate	3.15E-01	ND	ND	1.57E+00	ND	ND	2.39E-02	ND	ND
1,2-Dichlorobenzene	2.80E-06	3.66E+01	7.65E-08	NA	ND	NA	1.44E-11	ND	ND
1,4-Dichlorobenzene	7.02E-03	8.02E+00	8.75E-04	9.64E-04	ND	ND	4.34E-08	ND	ND
Ethyl benzene	5.60E-02	4.14E+01	1.35E-03	4.80E-06	ND	ND	6.88E-07	ND	ND
Fluoranthene	2.86E-02	2.90E-01	9.85E-02	6.96E-01	ND	ND	3.97E-05	ND	ND
Fluorene	1.01E-03	2.90E-01	3.48E-03	NA	ND	NA	1.62E-08	ND	ND

2-Methylnaphthalene	1.23E-02	2.90E-01	4.25E-02	NA	ND	NA	3.50E-11	ND	ND
Methylene Chloride	7.56E-03	3.10E+00	2.44E-03	NA	ND	NA	1.89E-09	ND	ND
Naphthalene	1.32E-02	2.90E-01	4.54E-02	NA	ND	NA	9.26E-08	ND	ND
Phenanthrene	2.55E-03	2.90E-01	8.79E-03	NA	ND	NA	6.44E-08	ND	ND
Pyrene	2.38E-03	2.90E-01	8.21E-03	NA	ND	NA	1.87E-07	ND	ND
Toluene	8.12E-02	7.40E+00	1.10E-02	NA	ND	NA	1.59E-07	ND	ND
Xylenes	6.33E-01	6.00E-01	1.05E+00	9.16E-04	ND	ND	5.28E-06	ND	ND
Pesticides/PCBs									
Aldrin	4.53E-04	1.06E-01	4.28E-03	1.15E-04	ND	ND	2.25E-09	ND	ND
Aroclor 1242	7.28E-03	4.70E-02	1.55E-01	NA	4.10E-01	NA	1.55E-06	4.10E-01	3.78E-06
Aroclor 1254	8.31E-03	9.60E-02	8.66E-02	1.64E-01	1.80E-01	9.09E-01	3.37E-05	1.80E-01	1.87E-04
4,4'-DDD	6.67E-05	4.20E-01	1.59E-04	6.93E-04	3.00E-03	2.31E-01	1.60E-07	3.00E-03	5.32E-05
4,4'-DDE	9.52E-06	4.20E-01	2.27E-05	NA	3.00E-03	ND	1.32E-09	3.00E-03	4.41E-07
4,4'-DDT	2.08E-04	4.20E-01	4.96E-04	8.84E-04	3.00E-03	2.95E-01	3.91E-07	3.00E-03	1.30E-04
Dieldrin	1.18E-04	1.10E-02	1.07E-02	NA	7.70E-02	ND	3.43E-09	7.70E-02	4.45E-08
Endosulfan I	4.76E-06	8.00E-02	5.95E-05	NA	1.00E+01	ND	3.35E-11	1.00E+01	3.35E-12
Endrin	2.60E-05	2.60E-02	1.00E-03	NA	1.00E-02	ND	3.14E-09	1.00E-02	3.14E-07
Beta BHC	4.76E-05	2.10E-01	2.27E-04	NA	ND	NA	4.45E-10	ND	ND
Totals:			1.54E+02			4.42E+02			1.22E+01

[1] NA = Not applicable.

[2] ND = Insufficient data to calculate value.

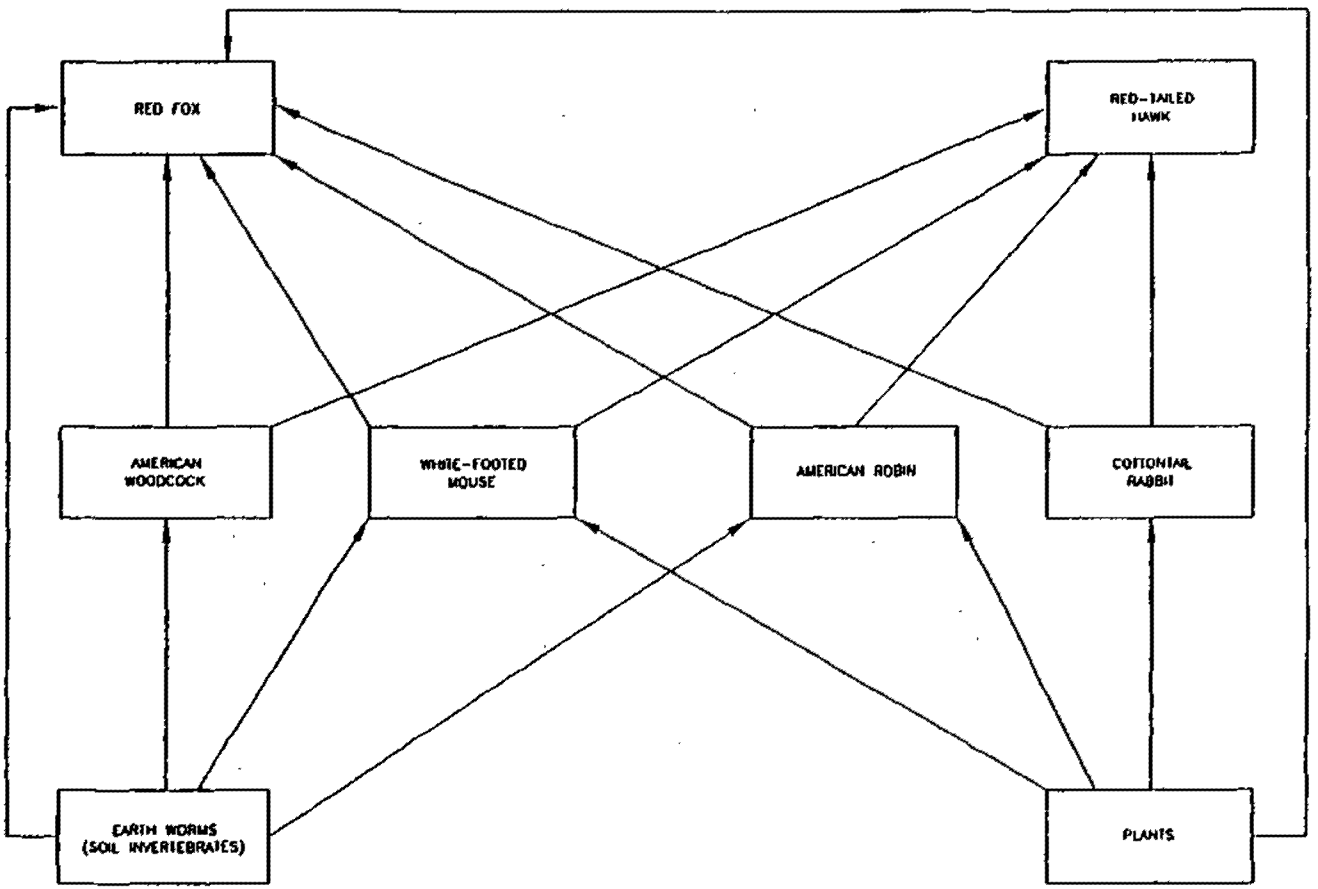
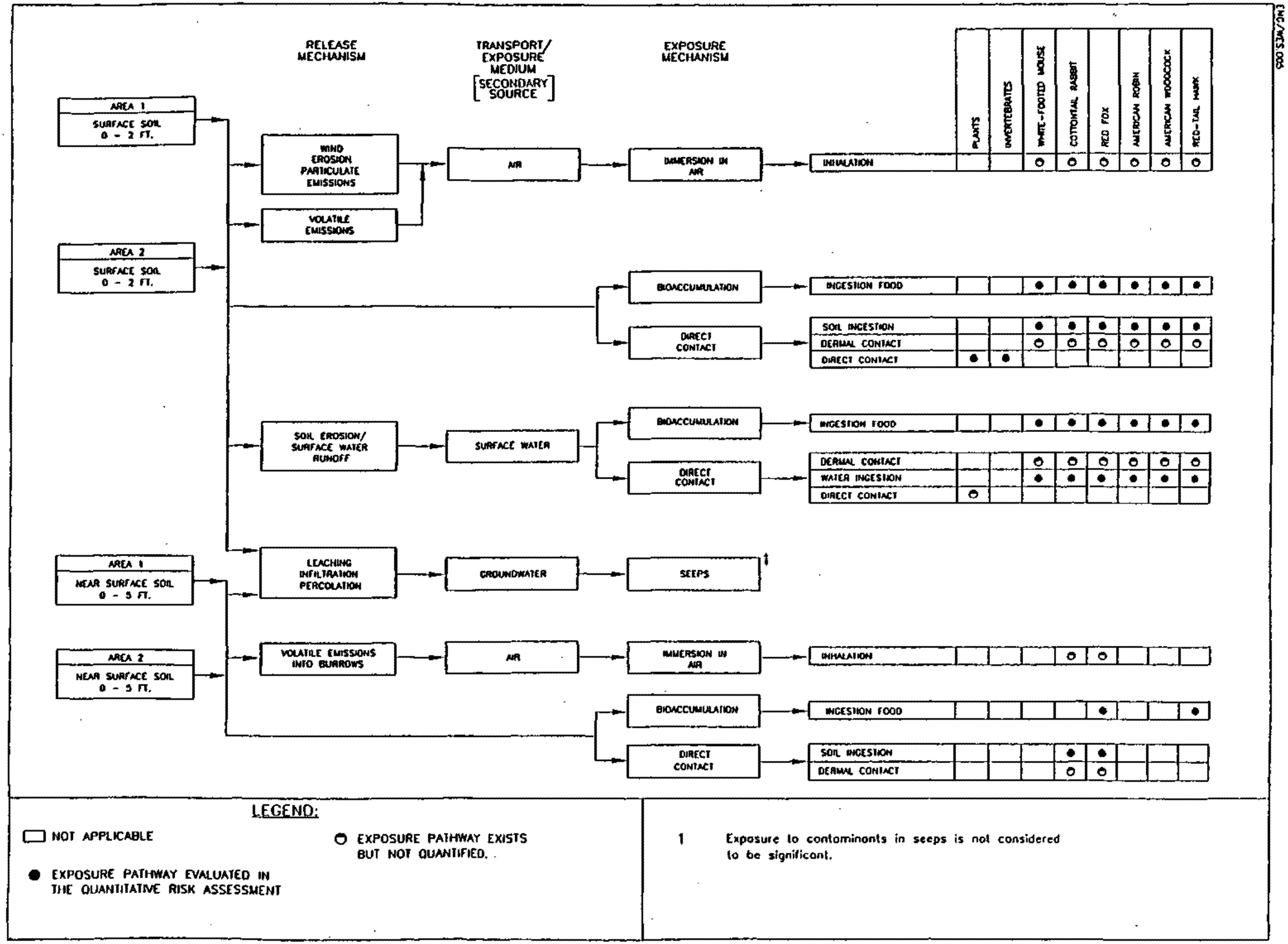


FIGURE A.7-1: Simplified Food Web



LEGEND:

- ▭ NOT APPLICABLE
- ● EXPOSURE PATHWAY EVALUATED IN THE QUANTITATIVE RISK ASSESSMENT
- ○ EXPOSURE PATHWAY EXISTS BUT NOT QUANTIFIED.

1 Exposure to contaminants in seeps is not considered to be significant.

FIGURE A.7-2: Conceptual Model

A.8.0 SUMMARY

This BRA has been prepared by A&A for EMSI on behalf of the "Respondents" Cotter Corporation (N.S.L.), Laidlaw Waste Systems (Bridgeton), Inc., Rock Road Industries, Inc., and the United States Department of Energy. The BRA has been prepared as part of the RI/FS for Operable Unit 1 at the West Lake Landfill located in Bridgeton, Missouri.

Operable Unit 1 consists of two areas on the landfill that contain radiologically impacted soils, Area 1 and Area 2, and a limited part of an adjacent property (Ford property).

A.8.1 CHEMICALS OF POTENTIAL CONCERN

The nature and extent of contamination within and around Operable Unit 1 has been characterized as part of the RI. The contaminated area primarily consists of two localized areas (Areas 1 and 2) containing soil with above-background concentrations of radioactive materials. In addition, a portion of the Ford property, adjacent to the landfill, has been found to have above-background concentrations of radioactive materials. The COPCs in these soils include members of the uranium, actinium, and thorium natural decay series and five non-radiological contaminants. Potential current and future exposures to these COPCs have been addressed in the exposure and toxicity assessments.

A.8.2 EXPOSURE ASSESSMENT

The potential for health effects from exposure to contaminants in Operable Unit 1 was estimated for hypothetical receptors located on the landfill and in areas adjacent to the landfill potentially affected by releases from Areas 1 and 2. Several possible receptor scenarios were initially considered as part of the exposure assessment. Characterization data describing the source term, existing access controls and restrictive covenants, and current and future projected land use were used to select the plausible receptor scenarios from this initial group. These scenarios included hypothetical grounds keeper, trespassers, adjacent building user parking on Areas 1 and 2, and ancillary use by adjacent property users such as storage yard worker receptors at the landfill and a hypothetical grounds keeper receptor on the Ford property.

The physical characteristics of Operable Unit 1 and likely receptor behavior patterns were used to identify potential exposure pathways to the hypothetical receptors (see Figure A.3-1 and Table A.3-1). Routes of exposure quantified in the BRA included exposure to external radiation, inhalation of dust and gas, dermal contact, and incidental ingestion of soil. The resulting calculated receptor radiation exposures and receptor radionuclide and chemical intakes were combined with the toxicity assessment presented in Section A.4.0 to characterize the risks.

A.8.3 TOXICITY ASSESSMENT

The toxicity assessment determined the mode of toxicity of the various COPCs (i.e., carcinogenic and systemic toxicity), and provided a quantitative measure of that toxicity. Carcinogens and toxicants were evaluated in this assessment using information from the EPA IRIS database (EPA 2000) and HEAST (EPA 1997c).

A.8.4 HUMAN HEALTH RISK CHARACTERIZATION

The results of this baseline risk assessment indicate that current receptor exposures are mitigated by the existence of access controls and were calculated to be within the 10^{-6} to 10^{-4} target risk range used by EPA at CERCLA sites (Table A.5-12). These results incorporate the conservative simplifying assumption that certain receptors actually have access to Areas 1 and 2. As the source term ages and the assumed activities on Areas 1 and 2 are performed in the future, risks are estimated to exceed 10^{-4} for the future grounds keeper and storage yard worker receptors (Table A.5-13).

It is important to note that these incremental risks to future workers at the site for the assumed radiation exposure scenarios are less than a few percent of the lifetime risk from natural background radiation exposures of the same persons. This is because the average radiation dose received by residents of the United States from natural background radiation sources corresponds to a calculated incremental lifetime cancer risk well over 10^{-2}. For example, the calculated incremental risks for future workers at the site are less than the difference in the calculated lifetime radiation risks that these persons would incur living in a brick house versus a wooden house during their lives.

The calculated risks for the future receptor scenarios located on the landfill are attributable to the presence of thorium-230 in the material buried within Areas 1 and 2. Because thorium-230 decays to radium-226, the concentration of radium-226 (and its short-lived daughters) will increase over time. This increase will lead to increasing external radiation levels and increasing radon-222 emanation from the ground surface within Operable Unit 1.

Non-radiological contaminants are not likely to cause an unacceptable risk to human health under either current or future conditions for any receptor scenarios evaluated at landfill locations within Operable Unit 1. Adverse systemic (noncarcinogenic) health effects are not expected because HIs are much less than 1 for exposure to COPCs.

Risks to a receptor located beyond the landfill property boundary were calculated for a hypothetical receptor scenario that assumed the presence of a grounds keeper on the adjacent Ford property. The carcinogenic risks to this hypothetical receptor were calculated to be approximately 10^{-6} for both current and future site conditions. The dominant exposure pathway for this receptor was determined to be external radiation exposure from radionuclides in soil.

A.8.5 UNCERTAINTY ASSESSMENT

A risk assessment contains uncertainties associated with measured or estimated quantities and uncertainties associated with a lack of information. Both of these forms of uncertainty can impact the results of the risk assessment, but the former uncertainty may be more quantifiable.

The uncertainty assessment was performed to identify those factors that have the greatest potential to affect the results of the risk assessment. It also has been used to evaluate the relative potential impact of those factors on the results of the risk assessment. All information used in the risk assessment was considered, including assumptions regarding the status of the operable unit, mathematical models used to quantify potential releases from the operable unit, and numerical parameter values used in quantifying exposures and risks.

Uncertainties associated with the risk assessment for Operable Unit 1 were identified and discussed in Section A.6.0. They are categorized and described with respect to the nature and extent of contamination, the quantitative source term, the conceptual model, and the models and numerical parameter values used in the calculations. In each case, the relative magnitude of

potential impact of these factors on the results of the risk assessment and the projected impact on health protectiveness introduced by each factor has been estimated. These estimates were summarized in Table A.6-1.

The results of the uncertainty assessment will be used along with the risk characterization results when remedial actions are considered for Operable Unit 1. Use of the numerical results of the risk characterization alone to make remedial action decisions, without consideration of inherent uncertainties, would result in less effective and less efficient application of the CERCLA remediation process.

The uncertainty assessment indicates that the decisions made in each phase of the risk assessment will most likely increase the overall health protectiveness or conservatism of the risk assessment. On an individual basis, all but one of the uncertainties that are estimated to have a moderate or high potential impact are considered to increase health protectiveness. Although the conservative exposures and risks hypothesized in the risk assessment might occur in a given population of interest, the probability of an individual actually being exposed at these levels of risk is considered to be low.

A.8.6 ECOLOGICAL RISK ASSESSMENT

The ecological risk assessment is a very conservative screening assessment used to evaluate the potential risk to ecological receptors exposed to chemicals in environmental media associated with Operable Unit 1. The risk assessment estimated potential exposure concentrations and intakes for various representative species and compared these values to acceptable exposure concentrations or doses (i.e., benchmark values), to determine if a potential risk to ecological receptors exists.

Based on the results of the screening risk assessment, plants and soil invertebrates may be adversely affected by metals present in soils in Operable Unit 1. Small burrowing mammals, passerine birds and terrestrial mammalian predators are at potential risk from exposure to metals in Operable Unit 1, especially metals in soils that have bioconcentrated into food items. Small burrowing mammals may be at risk from exposure to radionuclides in Area 2.

There is a significant amount of uncertainty associated with the information used to calculate the potential ecological risk results presented in this report. The ecological risk assessment dealt with this uncertainty by using conservative assumptions when estimating potential risks. For example, a range of COPC concentrations exists at the site. The exposure assessment used the maximum contaminant concentrations in conjunction with other conservative values to estimate the potential exposure of organisms. Using these maximum concentrations in the calculations may significantly overestimate the actual level of risk to ecological receptors. This suggests that contaminants present in Operable Unit 1 may not actually have a significant impact upon the environment, even though the screening assessment indicates the possible existence of impacts upon some ecological populations.

It should be noted that Areas 1 and 2 are located within a landfill operation. They currently support vegetative communities that provide habitat for wildlife. Sound post-closure landfill maintenance operations will result in the removal of the current vegetation and its replacement with grass that is mowed at least once a year. This destruction of habitat will likely drive many of the current wildlife species offsite. Therefore, addressing risks to current ecological receptors may not be representative of the potential ecological risks in the future, which are likely to be significantly lower than current risks.

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Attachment A.I

CALCULATION OF RADON IN OUTDOOR AIR

Concentrations of radon-222 in air within and adjacent to Area 1, Area 2, and the Ford property were calculated using a two-step process. First, the emanation of radon gas (radon-222) from the landfill surface was modeled using the computer model RAECOM (NRC 1984). RAECOM calculates the radon flux (pCi/m^2-s) exiting the surface of the landfill. Calculated radon flux values were used as input into the Nearfield Box Model (GRI 1988). This air dispersion model was then used to calculate the radon-222 concentrations (pCi/m^3) used in the human health risk assessment for Operable Unit 1.

A brief description of the RAECOM model and copies of the input and output files are presented in Section A.I.1. The Nearfield Box Model and its results are described in Section A.I.2.

A.I.1 RAECOM MODEL

RAECOM is a radon generation and transport code that was originally designed to analyze radon generation and emanation through uranium mill tailings waste and earthen cover materials. RAECOM has been used to calculate the radon flux from the surface soil within Area 1, Area 2, and the Ford property. It was selected because it can also be used to calculate health protective cover thickness and can be used during the feasibility study and remedial design phases of the CERCLA process.

A.I.1.1 Model Description

The RAECOM computer model requires a limited amount of information to estimate radon flux from the surface of a radon source layer and cover materials. Input parameters for the RAECOM model describe the dimensions and content of the source. These include the thickness of the radium-bearing material and the cover material layer (if any), the source strength expressed as radon-222 concentration in the pore space of each layer of source and cover material, and the porosity, moisture content, and radon gas diffusion coefficient for each layer.

RAECOM is based on a one-dimensional, multi-layer solution of Fick's law using the boundary conditions set forth in NUREG/CR-3533 (NRC 1984). For a bare source, this solution becomes:

$$J = 10^4 \cdot R \cdot \rho \cdot E \cdot \sqrt{\lambda \cdot D} \cdot \tanh\left[\sqrt{\frac{\lambda}{D}} \cdot x\right]$$

Eq. A.I- 1

where:

J	=	Radon flux from the source surface (pCi/m^2-s)
R	=	Concentration of radium-226 in the source (pCi/g)
ρ	=	Dry bulk density of source (g/cm^3)
E	=	Radon-222 emanation coefficient (unitless)
λ	=	Radiological decay constant of radon-222 (2.1 x 10^{-6} s^{-1})
x	=	Thickness of source (cm)
D	=	Radon diffusion coefficient in the material's pore space (cm^2/s)

The diffusion coefficient, D, is given by the empirical expression from Nielson and Rogers (1994):

$$D = P \cdot D_0 \cdot EXP\left[\left(-6 \cdot P \cdot \theta\right) - 6 \cdot \theta^{14 \cdot P}\right]$$

Eq. A.I- 2

where:

D_0	=	Diffusion coefficient for radon-222 in air (0.11 cm^2/s)
P	=	Porosity of source material (unitless), and
θ	=	Fractional moisture saturation of source material (unitless)

A.I.1.2 Application of RAECOM

Input parameters required to run RAECOM include the layer thickness (x), the radon-222 diffusion coefficient (D), the porosity (P), the moisture content (θ), and the pore space radon-222 source term (S). The pore space radon-222 source term (S) is given by Equation A.I-3 from (NRC 1984):

$$S = \frac{R \cdot \rho \cdot E \cdot \lambda}{P}$$

Eq. A.I- 3

The parameter values used to calculate S and D for materials in Area 1, Area 2, and the Ford property are given in Table A.I-1. These parameter values reflect the assumption that the radiologically impacted materials are homogeneously distributed through the entire volume of the source. The application of the RAECOM model to Area 1, Area 2, and the Ford Property

incorporates the simplifying assumptions that the source is not covered, and that radium-226 is homogeneously distributed through the entire source volume.

A.I.1.3 RAECOM Input and Output

Copies of the RAECOM input and output files for the Area 1, Area 2, and the Ford property radon calculations are presented below.

Input File for Area 1 Radon Calculation

```
RAECOM CALCULATION OF WESTLAKE OU1 - Area 1, All Depths, Future Conditions
1, 0., 0., 0, 0., .001
300.,   .0232,   .58, .00034, 29.0
```

Output File for Area 1 Radon Calculation

```
 RAECOM CALCULATION OF WESTLAKE OU1 - Area 1, All Depths, Future Conditions

   ********** INPUT PARAMETERS **********

 NUMBER OF LAYERS:                    1
 RADON FLUX INTO LAYER 1:              .000    pCi/m2/sec
 SURFACE RADON CONCENTRATION:          .000    pCi/LITER
 BARE SOURCE FLUX (Jo) FROM LAYER 1:  205.9    pCi/m2/sec

 LAYER  THICKNESS       DIFF COEFF      POROSITY        SOURCE        MOISTURE
          (cm)          (cm2/SEC)                   (pCi/cm3/sec)    (dry wt. %)
   1      300.           .2320E-01        .5800         .3400E-03      29.00


***** RESULTS OF RADON DIFFUSION CALCULATION*****

       LAYER   THICKNESS       EXIT FLUX          EXIT CONC.         MIC
                 (cm)        (pCi/m2/sec)        (pCi/liter)
         1       300.          .2059E+03          .0000E+00        .5804
```

Input File for Area 2 Radon Calculation

```
RAECOM CALCULATION OF WESTLAKE OU1 - Area 2, All Depths, Future Conditions
1, 0., 0., 0, 0., .001
300.,   .0232,   .58, .00124, 29.0
```

Output File for Area 2 Radon Calculation

```
 RAECOM CALCULATION OF WESTLAKE OU1 - Area 2, All Depths, Future Conditions

   ********** INPUT PARAMETERS **********

 NUMBER OF LAYERS:                    1
 RADON FLUX INTO LAYER 1:              .000    pCi/m2/sec
 SURFACE RADON CONCENTRATION:          .000    pCi/LITER
 BARE SOURCE FLUX (Jo) FROM LAYER 1:  750.9    pCi/m2/sec
```

```
LAYER  THICKNESS      DIFF COEFF      POROSITY       SOURCE        MOISTURE
          (cm)        (cm2/SEC)                  (pCi/cm3/sec)    (dry wt. %)
  1       300.         .2320E-01        .5800        .1240E-02       29.00


***** RESULTS OF RADON DIFFUSION CALCULATION*****

      LAYER   THICKNESS       EXIT FLUX          EXIT CONC.         MIC
                 (cm)       (pCi/m2/sec)        (pCi/liter)
        1        300.         .7509E+03          .0000E+00        .5804
```

Input File for Ford property Radon Calculation

```
RAECOM CALCULATION OF WESTLAKE OU1 - Ford Property, 0-2 ft, Future Conditions
1, 0., 0., 0, 0., .001
60.,   .0232,   .58, .0000173, 29.0
```

Output File for Ford property Radon Calculation

```
RAECOM CALCULATION OF WESTLAKE OU1 - Ford Property, 0-2 ft, Future Conditions

  ********** INPUT PARAMETERS **********

NUMBER OF LAYERS:                    1
RADON FLUX INTO LAYER 1:              .000    pCi/m2/sec
SURFACE RADON CONCENTRATION:          .000    pCi/LITER
BARE SOURCE FLUX (Jo) FROM LAYER 1:  5.442    pCi/m2/sec

LAYER  THICKNESS      DIFF COEFF      POROSITY       SOURCE        MOISTURE
          (cm)        (cm2/SEC)                  (pCi/cm3/sec)    (dry wt. %)
  1        60.         .2320E-01        .5800        .1730E-04       29.00


***** RESULTS OF RADON DIFFUSION CALCULATION*****

      LAYER   THICKNESS       EXIT FLUX          EXIT CONC.         MIC
                 (cm)       (pCi/m2/sec)        (pCi/liter)
        1         60.         .5442E+01          .0000E+00        .5804
```

A.I.1.4 RAECOM Results

The following table lists the radon fluxes calculated using RAECOM:

RAECOM Results

Area	Value	Units
Area 1 radon flux	205	pCi/m^2-s
Area 2 radon flux	753	pCi/m^2-s
Ford Property radon flux	0.42	pCi/m^2-s

A.I.2 NEARFIELD BOX MODEL

The Nearfield Box Model (GRI 1988) was used to calculate radon-222 concentrations in air in Area 1, Area 2, and the Ford Property. The model has the advantages of being both simple and robust. It is used to calculate air concentrations very near the source, a feature that is generally not available with more complex dispersion codes like the Industrial Source Complex - Long Term computer model (EPA 1995).

A.I.2.1 Nearfield Box Model Description

Input parameters required by the box model include the flux from the source area, the source dimensions, the wind speed, the mixing height, and the wind direction frequency. Concentrations of radon-222 in air are calculated using the following equation:

$$C = \frac{Q \cdot F}{H \cdot W \cdot U_m}$$

Eq. A.I- 4

where:

- C = Concentration of radon-222 in ambient air (pCi/m^3)
- Q = Emission rate of radon-222 (pCi/sec)
- H = Mixing height (m)
- W = Width of crosswind dimension of source area (m)
- U_m = Average wind speed in open field = $0.22 \bullet U_{10} \bullet \ln[2.5 \bullet H]$ (m/sec) (GRI, 1988)
- U_{10} = Wind speed at 10 m above ground surface (m/sec)
- F = Fraction of time wind blows toward exposure point (unitless)

and

$$Q = (J)(A)$$

Eq. A.I- 5

where:

- J = Flux rate ($pCi/m^2 \cdot sec$)
- A = Source area (m^2)

A.I.2.2 Nearfield Box Model Input

The values selected for use in the Nearfield Box Model are presented in Table A.I-2.

A.I.2.3 Nearfield Box Model Results

Calculated radon concentrations for Area 1, Area 2, and the Ford property are provided below:

Radon-222 Levels in Air as Calculated Using the Nearfield Box Model

Area	Value	Units
Area 1	19	pCi/m^3
Area 2	67	pCi/m^3
Ford Property	0.04	pCi/m^3

Table A.I-1 Parameter Values used to Prepare Input Files for RAECOM Runs on Operable Unit 1

Parameter Name	Symbol	Value Used	Units	References
Referenced Values				
Porosity	P	0.58	unitless	EMSI 1997
Density	ρ	1.13	g/cm^3 (dry)	EMSI 1997
Moisture	θ	0.29	dry wt frac	EMSI 1997
Radon emanation coefficient	E	0.2	unitless	NRC (1984)
Layer thickness in Area 1	x	300	cm	Based on boring logs
Layer thickness in Area 2	x	300	cm	Based on boring logs
Layer thickness in Ford Property	x	15	cm	Based on boring logs
Radium-226 concentration for Area 1	R	416	pCi/g	Table A.3-5 [a]
Radium-226 concentration for Area 2	R	1525	pCi/g	Table A.3-6 [a]
Radium-226 concentration for Ford Property	R	6	pCi/g	Table A.3-7 [a]
Calculated Values				
Diffusion Coefficient	D	0.0232	cm^2/s	Equation A.I-2
Pore space radon-222 source term, Area 1	S	3.4 E-4	$pCi/cm^3/s$	Equation A.I-3
Pore space radon-222 source term, Area 2	S	1.2 E-3	$pCi/cm^3/s$	Equation A.I-3
Pore space radon-222 source term, Ford Property	S	4.9 E-6	$pCi/cm^3/s$	Equation A.I-3

[a] Radium-226 concentration, after 1000 years of in-growth.

Table A.I-2 Input Parameter Values Used in the Nearfield Box Model to Calculate Radon-222 Concentrations in Air at the Westlake Landfill

Parameter		Value		
Name	Symbol	Used	Units	References
Area 1				
Source area	A	18023	m^2	EMSI 1998
Source width	W	152	m	EMSI 1997
Box height	H	118	m	Length of Source[a]
Mean wind speed at 10 m	U_{10}	4.35	m/s	St Louis Airport[b]
Fraction of time spent downwind	F	0.5	unitless	Assumption
Area 2				
Source area	A	75714	m^2	EMSI 1998
Source width	W	518	m	EMSI 1997
Box height	H	146	m	Length of Source[a]
Mean wind speed at 10 m	U_{10}	4.35	m/s	St Louis Airport[b]
Fraction of time spent downwind	F	0.5	unitless	Assumption
Ford Property				
Source area	A	18208	m^2	EMSI 1998
Source width	W	183	m	EMSI 1998
Box height	H	100	m	Length of Source[a]
Mean wind speed at 10 m	U_{10}	4.35	m/s	St Louis Airport[b]
Fraction of time spent downwind	F	0.5	unitless	Assumption

[a] Assumes a rise rate of 1 meter for every 1 meter traveled over the source.
[b] 1988 – 1992 five year average of data collected at St. Louis Airport.

A.I.3 REFERENCES

EMSI 1998 - Environmental Management Support, Inc, March 1998, Remedial Investigation Report, West Lake Landfill, Operable Unit 1.

EMSI 1997 - Environmental Management Support, Inc, 1997, Interim Investigation Results Technical Memorandum, West Lake Landfill, Operable Unit 1.

GRI 1988 - Gas Research Institute, 1988, "Management of Manufactured Gas Plant Sites, Volume III," prepared by the Atlantic Environmental Services, Inc. for the Gas Research Institute.

Nielson and Rogers 1994 - Kirk K. Neilson, Vern C. Rogers, Vern Rogers, and Rodger Holt, 1994, "The RAETRAD Model of Radon Generation and Transport from Soils into Slab-On-Grade Houses," Health Physics Journal, Vol. 67(4).

EPA 1995 - U.S. Environmental Protection Agency, 1995, "User's Guide for the Industrial Source Complex (ISC3) Dispersion Models - Volumes 1 and 2," prepared by Pacific Environmental Services, Inc. Research Triangle Park, North Carolina for US EPA Office of Air Quality Planning and Standards Emissions, Monitoring, and Analysis Division.

NRC 1984 - U.S. Nuclear regulatory Commission, 1984, "Radon Attenuation Handbook for Uranium Mill Tailings Cover Design," NUREG/CR-3533, PNL-4878, prepared by Rogers and Associates Engineering Corp. and Battelle Pacific Northwest Laboratory for the NRC, Washington, DC.

Attachment A.II

RESTRICTIVE COVENANTS

SPENCER FANE BRITT & BROWNE LLP
ATTORNEYS AND COUNSELORS AT LAW

MICHAEL D. HOCKLEY
DIRECT DIAL (816) 292-8233
mdh@spencerfane.com

File No. 2741000/1

July 30, 1997

David A. Hoefer, Esq.
Assistant Regional Counsel
Office of Regional Counsel
U.S. Environmental Protection Agency
Region VII
726 Minnesota Avenue
Kansas City, Kansas 66101

Re: West Lake Landfill Site, Declaration of Covenants and Restrictions

Dear David:

With this letter I enclose copies of the following documents:

1. Declaration of Covenants and Restrictions executed by West Lake Quarry and Material Company, recorded with the St. Louis County Recorder of Deeds on June 30, 1997 at Book 11208, Page 2499;

2. Declaration of Covenants and Restrictions executed by Rock Road Industries, Inc., recorded with the St. Louis County Recorder of Deeds on June 30, 19997 at Book 11208, Page 2508;

3. Declaration of Covenants and Restrictions executed by Laidlaw Waste Systems (Bridgeton) Inc., recorded with the St. Louis County Recorder of Deeds on June 30, 1997 at Book 11208, Page 2515.

By recording these Declarations of Covenants and Restrictions, future use of the area encompassed by the West Lake Superfund Site has been limited and cannot include residential use. To change such use, the Environmental Protection Agency, the Missouri Department of Natural Resources, and the owner of the affected premises would have to agree to such changes. Therefore, the West

212540.1

Lake Landfill Site Respondents believe that the only reasonable future use that should be considered for risk assessment purposes is a non-residential use.

Sincerely,

Michael D. Hockley

MDH:nrl

cc: Mr. Doug Borro
William R. Werner, Esq.
Charlotte L. Neitzel, Esq.
Mr. James W. Wagoner II
Mr. Paul V. Rosasco, P.E.
(All via mail, w/enclosure)

212540.1

BP11208/2499

[redacted]

199706300082 9

DANIEL T. O'LEARY
RECORDER OF DEEDS
ST. LOUIS COUNTY MISSOURI
41 SOUTH CENTRAL
CLAYTON, MO 63105

RECORDER OF DEEDS DOCUMENT IDENTIFICATION & CERTIFICATION SHEET

TYPE OF INSTRUMENT	GRANTOR	TO	GRANTEE
RESTR	WEST LAKE QUARRY AND MATERIAL CO ETAL		

PROPERTY DESCRIPTION: YOSTI PARTITION LOT PT 1 2 3 & 4

Lien Number	Notation	Document Number	Locator
		829	

STATE OF MISSOURI)
SS.
COUNTY OF ST. LOUIS)

I, the undersigned Recorder of Deeds for said County and State, do hereby certify that the following and annexed instrument of writing, which consists of 8 pages, (this page inclusive), was filed for record in my office on the 30 day of June 1997 at 02:30 PM and is truly recorded in the book and at the page shown at the top and/or bottom of this page.

In witness whereof I have hereunto set my hand and official seal the day, month and year aforesaid.

SEAL OF THE RECORDER OF DEEDS FOR ST. LOUIS COUNTY, MO

Daniel T. O'Leary
Recorder of Deeds
St. Louis County, Missouri

J. Allen
Deputy Recorder

RECORDING FEE $36.32

7

DECLARATION OF COVENANTS AND RESTRICTIONS

WEST LAKE QUARRY AND MATERIAL COMPANY

West Lake Quarry and Material Company, a Missouri corporation ("Declarant"), hereby (a) imposes the provisions of this Declaration upon the Premises (as defined below), (b) publishes and declares that the following terms, conditions, restrictions and obligations shall (i) affect and encumber the Premises, (ii) run with and be a burden upon and a benefit to the Premises, and (iii) be fully binding upon Declarant and all other persons or entities acquiring the Premises or any part thereof or interest therein whether by descent, devise, purchase or otherwise, and (c) declares that any person or entity, by the acceptance of title to the Premises or any part thereof or interest therein, shall thereby agree and covenant to abide by and be bound by the following terms, conditions, restrictions and obligations.

RECITALS

A. Declarant is the owner of certain real property (located in the City of Bridgeton, County of St. Louis, State of Missouri), legally described on Exhibit A, attached hereto and incorporated herein by this reference, which real property is herein referred to as the "Premises".

B. The Premises and nearly all real property in the immediate vicinity of the Premises have been used exclusively for more than 40 years for non-residential uses, primarily for commercial and industrial uses and in some cases, for agricultural uses.

C. Such uses have included, but have not been limited to, quarrying operations, demolition and sanitary landfill operations, asphalt and concrete batch plant operations, and vehicle maintenance, repair and body shop operations.

D. Such uses, and the character and nature of the land uses in the vicinity of the Premises, make the Premises unsuitable for any future residential use.

E. The United States Environmental Protection Agency ("EPA") has entered into an Administrative Order on Consent (the "Consent Order") with Cotter Corporation (N.S.L.), Laidlaw Waste Systems (Bridgeton) Inc., Rock Road Industries, Inc., and the United States Department of Energy.

F. The Consent Order, among other things, (i) provides for the investigation of the nature and extent of contamination and any threat to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances at or from two isolated areas either on or in the vicinity of the Premises and which have been designated as Radiological Areas 1 and 2 in the Consent Order, and which contain low-level radioactive waste materials, and (ii) has been filed with the Regional Hearing Clerk, EPA, Region VII, 726 Minnesota Avenue, Kansas City, Kansas, Docket No. VII-93-F-0005.

G. Declarant desires to prohibit the present and future use of the Premises for any residential purpose in accordance with the terms and provisions of this Declaration.

DECLARATION

Declarant hereby states and declares as follows:

1. Neither the Premises, nor any portion thereof, shall be used now or hereafter for any residential purpose, or for any day care, preschool or other educational use.

2. This Declaration shall not unlawfully restrict and shall not be used to violate any federal law, rule, or regulation regarding the use of real estate, including, but not limited to, the Fair Housing Act.

3. No water well for drinking water use shall be installed on the Premises.

4. This Declaration shall be recorded in the office of the Recorder of Deeds for the County of St. Louis, State of Missouri.

5. Any deed or other instrument of conveyance for the Premises or any portion thereof shall be subject to this Declaration.

6. Each of EPA (or its successor), the Missouri Department of Natural Resources ("MDNR") (or its successor) and the owner of any portion of the Premises shall have the right to sue for and obtain an injunction, prohibitive or mandatory, to prevent the breach, or to enforce the observance, of this Declaration. This right shall be in addition to any other action available at law or in equity. The failure to enforce any covenant or restriction herein at the time of its violation shall not constitute a waiver of the right to do so later.

7. The provisions of this Declaration shall continue in full force and effect until the fiftieth anniversary of the date of this Declaration and thereafter for successive twenty-year periods unless, prior to the expiration of the then current term, a written notice of termination of this Declaration, executed by each of the then owners of the Premises and by authorized representatives of EPA (or its successor) and MDNR (or its successor), has been filed with the office of the Recorder of Deeds for St. Louis County, State of Missouri. A notice of termination of this Declaration may be filed at any time after the effective date of this Declaration, and the Declaration shall terminate on the date the notice of termination is filed with the Recorder of Deeds.

IN WITNESS WHEREOF, West Lake Quarry and Material Company has caused this instrument to be executed this 27th day of May, 1998.

WEST LAKE QUARRY AND MATERIAL COMPANY
a Missouri corporation

By: _____
William E. Whitaker
President

ACKNOWLEDGEMENT

STATE OF MISSOURI)
) ss
County OF ST. LOUIS)

On this 27th day of May, 1998, before me, a notary public, personally appeared William E. Whitaker, to me known, who, being by me duly sworn, did say that he is the President of West Lake Quarry and Material Company, a Missouri corporation, and that said instrument was signed on behalf of said corporation by authority of its Board of Directors, and said person acknowledged said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal in the County and State aforesaid, the day and year first above written.

Margaret G. Cusumano
Notary Public

My Commission Expires:

November 5, 1998

MARGARET G CUSUMANO
NOTARY PUBLIC STATE OF MISSOURI
ST. LOUIS COUNTY
MY COMMISSION EXP. NOV. 5,1998

GRANTOR'S PROPERTY

A tract of land in part of Lots 1,2,3, and 4 of the Yosti Partition in U.S. Survey 131, part of Lot 21, of the St. Charles Ferry Company Tract in U.S. Survey 47 and 1934, part of U.S. Survey 131, and part of U.S. Survey 47 in Townships 46 and 47 North, Range 5 East of the 5th Principal Meridian, St. Louis County Missouri, described as follows:

Beginning at the most easterly corner of Lot 1 of the Yosti Partition in U.S. Survey 131, being a point in the centerline of Taussig Avenue; thence South 43 degrees 34 minutes 53 seconds East, along the northeasterly line of Lot 4 of the Yosti Partition, a distance of 99.92; thence South 6 degrees 41 minutes 15 seconds West, a distance of 68.96 feet; thence South 23 degrees 21 minutes 55 seconds West, a distance of 154.73 feet; thence South 26 degrees 49 minutes 07 East, a distance of 55.27 feet; thence South 14 degrees 32 minutes 36 seconds West, a distance of 143.63 feet; thence South 34 degrees 03 minutes 12 seconds West, a distance of 220.86 feet; thence North 55 degrees 41 minutes 34 seconds West, a distance of 127.00 feet; thence South 88 degrees 59 minutes 19 seconds West, a distance of 62.24 feet; thence South 54 degrees 43 minutes 18 seconds West, a distance of 240.50 feet; thence South 26 degrees 44 minutes 32 seconds West, a distance of 450.91 feet; thence South 8 degrees 25 minutes 49 seconds West, a distance of 224.01 feet; thence South 17 degrees 14 minutes 43 seconds East, a distance of 28.63 feet; thence South 47 degrees 09 minutes 44 seconds East, a distance of 61.27 feet; thence South 24 degrees 34 minutes 10 seconds East, a distance of 73.64 feet; thence South 0 degrees 07 minutes 21 seconds West, a distance of 107.37 feet to the northeasterly right of way line of the St. Charles Rock Road, 60 foot wide; thence North 61 degrees 07 minutes 11 seconds West, along said right of way line, a distance of 99.72 feet to the centerline of Taussig Avenue; thence North 28 degrees 07 minutes 01 seconds East, along said centerline, a distance of 100.00 feet to the intersection of said centerline and the southeasterly prolongation of the northeasterly line of a tract of land conveyed to American Telephone and Telegraph Company of Missouri by deed recorded in Book 1719 on Page 170; thence North 61 degrees 07 minutes 11 seconds West, along said line, a distance of 120.00 feet to the most northerly corner of said tract; thence South 28 degrees 07 minutes 01 seconds West, along the northwesterly line of said tract and its southwesterly extension, a distance of 130.00 feet to the centerline of the St. Charles Rock Road; thence North 61 degrees 07 minutes 11 seconds West, along said centerline a distance of 252.27 feet; thence North 51 degrees 56 minutes 32 seconds East, a distance of 311.60 feet; thence North 26 degrees 44 minutes 32 seconds East, a distance of 644.89 feet; thence North 56 degrees 34 minutes 13 seconds West, a distance of 296.04 feet; thence North 49 degrees 02 minutes 55 seconds West, a distance of 174.81 feet; thence North 7 degrees 43 minutes 38 seconds West, a distance of 65.61 feet; thence South 82 degrees 16 minutes 22 seconds West, a distance of 106.78 feet; thence around a curve to the right, having a radius of 150.00 feet and a chord bearing North 47 degrees 50 minutes 16 seconds West, a chord distance of 229.44 feet to a point of compound curve; thence around a curve to the right, having a radius of 450.00 feet and a chord bearing North 30 degrees 29 minutes 30 seconds East, a chord distance of 428.61 feet to its point of tangency; thence North 58 degrees 55 minutes 53 seconds East. a distance of 277.03 feet: thence North 2

degrees 03 minutes 23 seconds West, a distance of 332.12 feet; thence North 43 degrees 55 minutes 12 seconds West, a distance of 444.12 feet; thence North 39 degrees 22 minutes 26 seconds East, a distance of 463.83 feet; thence North 53 degrees 20 minutes 34 second East, a distance of 126.98 feet; thence South 50 degrees 18 minutes 12 seconds East, a distance of 205.86 feet; thence North 75 degrees 52 minutes 00 seconds East, a distance of 426.11 feet; thence North 51 degrees 12 minutes 40 seconds East, a distance of 277.46 feet to the southwesterly right of way line of Highway 40; also known as St. Charles Rock Road; thence South 43 degrees 53 minutes 31 seconds East, along said right of way line, a distance of 137.18 feet; thence leaving said right of way, South 51 degrees 12 minutes 40 seconds West, a distance of 1023.23 feet; thence South 25 degrees 58 minutes 41 seconds West, a distance of 181.33 feet to the northeasterly line of Lot 1 of the Yosti Partition of U.S. Survey 131; thence South 43 degrees 34 minutes 53 seconds East, along said northeasterly line, a distance of 971.20 feet to the Point of Beginning.

Excepting from the above the following:

A tract of land being part of Lots 1, 3, and 4 of the "Yosti Partition in U.S. Survey 131, townships 46 and 47 north, range 5 east of the Fifth Principal Meridian, St. Louis County, Missouri, more particularly described as follows:

Commencing at the intersection of the northwesterly line of U.S. Survey 131 and the southwesterly right of way line of Highway 40, also known as "St. Charles Rock Road;" thence South 37 degrees 11 minutes 39 seconds East, along said south right of way line, 209.98 feet; thence exiting said right of way line, South 57 degrees 54 minutes 32 seconds West, 1023.23 feet; thence South 32 degrees 40 minutes 33 seconds West, 181.33 feet to the northeasterly line of said lot 1; thence South 36 degrees 53 minutes 01 seconds East, along said northeasterly line of lot 1, a distance of 591.05 feet to the point of beginning of the tract described herein; thence continuing along the northeasterly line of said lot 1 and along the northeasterly line of said lot 4, South 36 degrees 53 minutes 01 seconds East, 480.07 feet; thence exiting said northeasterly line, South 13 degrees 23 minutes 07 seconds West, 68.96 feet; thence South 30 degrees 03 minutes 47 seconds West, 154.73 feet; thence South 20 degrees 07 minutes 14 seconds East; 55.27 feet; thence South 21 degrees 14 minutes 28 seconds West, 143.63 feet; thence South 40 degrees 45 minutes 05 seconds West, 220.86 feet; thence North 48 degrees 59 minutes 42 seconds West, 127.00 feet; thence North 84 degrees 18 minutes 49 seconds West, 62.24 feet; thence South 61 degrees 25 minutes 10 seconds West, 240.50 feet; thence South 33 degrees 26 minutes 24 seconds West, 450.91 feet; thence South 15 degrees 07 minutes 41 seconds West, 224.01 feet; thence South 10 degrees 32 minutes 51 seconds East, 28.63 feet; thence South 40 degrees 27 minutes 52 seconds East, 61.27 feet; thence South 17 degrees 52 minutes 18 seconds East, 73.64 feet; thence South 06 degrees 49 minutes 13 seconds West, 107.37 feet to the north right of way line of "Old St. Charles Rock Road;" thence North 54 degrees 25 minutes 19 seconds West, along said right of way line, 99.72 feet; thence North 34 degrees 48 minutes 53 seconds East, 100.00 feet; thence exiting said west line, North 54 degrees 25 minutes 19 seconds West, 120.00 feet; thence North 21 degrees 27 minutes 09 seconds East, 153.52 feet; thence North 00 degrees 02 minutes 46 seconds West, 37.43 feet; thence North 56 degrees 33 minutes 36 seconds West, 70.00 feet; thence North 33 degrees 26 minutes 24 seconds East, 624.89 feet; thence South 49 degrees 52 minutes 21 seconds East, 56.85 feet; thence North 67 degrees 30 minutes 55 seconds East, 206.05 feet; thence North 08 degrees 48 minutes 44 seconds East, 158.15 feet; thence South 59 degrees 03 minutes 26 seconds East, 82.21 feet; thence North 33 degrees 28 minutes 55 seconds East, 321.44 feet; thence North 55 degrees 02 minutes 11 seconds West, 158.34 feet; thence North 01 degrees 10 minutes 17 seconds East, 342.38 feet to the point of beginning.

BK11208/2507

[redacted]

199706300083O

DANIEL T. O'LEARY
RECORDER OF DEEDS
ST. LOUIS COUNTY MISSOURI
41 SOUTH CENTRAL
CLAYTON, MO 63105

RECORDER OF DEEDS DOCUMENT IDENTIFICATION & CERTIFICATION SHEET

TYPE OF INSTRUMENT	GRANTOR	TO	GRANTEE
RESTR	ROCK ROAD INDUSTRIES INC ETAL		

PROPERTY DESCRIPTION: SUR 131 T 47 R 5 W/O/P

Lien Number	Notation	Document Number	Locator
		830	

STATE OF MISSOURI)
SS.
COUNTY OF ST. LOUIS)

I, the undersigned Recorder of Deeds for said County and State, do hereby certify that the following and annexed instrument of writing, which consists of 7 pages, (this page inclusive), was filed for record in my office on the 30 day of June 1997 at 02:30 PM and is truly recorded in the book and at the page shown at the top and/or bottom of this page.

In witness whereof I have hereunto set my hand and official seal the day, month and year aforesaid.

SEAL OF THE RECORDER OF DEEDS FOR ST. LOUIS COUNTY, MO

Recorder of Deeds
St. Louis County, Missouri

Deputy Recorder

RECORDING FEE $33.32

(Paid at the time of Recording)

V

DECLARATION OF COVENANTS AND RESTRICTIONS

ROCK ROAD INDUSTRIES, INC.

Rock Road Industries, Inc., a Missouri corporation ("Declarant"), hereby (a) imposes the provisions of this Declaration upon the Premises (as defined below), (b) publishes and declares that the following terms, conditions, restrictions and obligations shall (i) affect and encumber the Premises, (ii) run with and be a burden upon and a benefit to the Premises, and (iii) be fully binding upon Declarant and all other persons or entities acquiring the Premises or any part thereof or interest therein whether by descent, devise, purchase or otherwise, and (c) declares that any person or entity, by the acceptance of title to the Premises or any part thereof or interest therein, shall thereby agree and covenant to abide by and be bound by the following terms, conditions, restrictions and obligations.

RECITALS

A. Declarant is the owner of certain real property (located in the City of Bridgeton, County of St. Louis, State of Missouri), legally described on Exhibit A, attached hereto and incorporated herein by this reference, which real property is herein referred to as the "Premises".

B. The Premises and nearly all real property in the immediate vicinity of the Premises have been used exclusively for more than 40 years for non-residential uses, primarily for commercial and industrial uses and in some cases, for agricultural uses.

C. Such uses have included, but have not been limited to, quarrying operations, demolition and sanitary landfill operations, asphalt and concrete batch plant operations, and vehicle maintenance, repair and body shop operations.

D. Such uses, and the character and nature of the land uses in the vicinity of the Premises, make the Premises unsuitable for any future residential use.

E. The United States Environmental Protection Agency ("EPA") has entered into an Administrative Order on Consent (the "Consent Order") with Cotter Corporation (N.S.L.), Declarant, Laidlaw Waste Systems (Bridgeton) Inc., and the United States Department of Energy.

F. The Consent Order, among other things, (i) provides for the investigation of the nature and extent of contamination and any threat to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances at or from two isolated areas either on or in the vicinity of the Premises and which have been designated as Radiological Areas 1 and 2 in the Consent Order, and which contain low-level radioactive waste materials, and (ii) has been filed with the Regional Hearing Clerk, EPA, Region VII, 726 Minnesota Avenue, Kansas City, Kansas, Docket No. VII-93-F-0005.

G. Declarant desires to prohibit the present and future use of the Premises for any residential purpose in accordance with the terms and provisions of this Declaration.

DECLARATION

Declarant hereby states and declares as follows:

1. Neither the Premises, nor any portion thereof, shall be used now or hereafter for any residential purpose, or for any day care, preschool or other educational use.

2. This Declaration shall not unlawfully restrict and shall not be used to violate any federal law, rule, or regulation regarding the use of real estate, including, but not limited to, the Fair Housing Act.

3. No water well for drinking water use shall be installed on the Premises.

4. This Declaration shall be recorded in the office of the Recorder of Deeds for the County of St. Louis, State of Missouri.

5. Any deed or other instrument of conveyance for the Premises or any portion thereof shall be subject to this Declaration.

6. Each of EPA (or its successor), the Missouri Department of Natural Resources ("MDNR") (or its successor) and the owner of any portion of the Premises shall have the right to sue for and obtain an injunction, prohibitive or mandatory, to prevent the breach, or to enforce the observance, of this Declaration. This right shall be in addition to any other action available at law or in equity. The failure to enforce any covenant or restriction herein at the time of its violation shall not constitute a waiver of the right to do so later.

7. The provisions of this Declaration shall continue in full force and effect until the fiftieth anniversary of the date of this Declaration and thereafter for successive twenty-year periods unless, prior to the expiration of the then current term, a written notice of termination of this Declaration, executed by each of the then owners of the Premises and by authorized representatives of EPA (or its successor) and MDNR (or its successor), has been filed with the office of the Recorder of Deeds for St. Louis County, State of Missouri. A notice of termination of this Declaration may be filed at any time after the effective date of this Declaration, and the Declaration shall terminate on the date the notice of termination is filed with the Recorder of Deeds.

IN WITNESS WHEREOF, Rock Road Industries, Inc. has caused this instrument to be executed this 27th day of May, 1997.

ROCK ROAD INDUSTRIES, INC.
a Missouri corporation

By: _____
William E. Whitaker
President

ACKNOWLEDGEMENT

STATE OF MISSOURI)
) ss
County OF ST. LOUIS)

On this 27th day of May, 1997, before me, a notary public, personally appeared William E. Whitaker, to me known, who, being by me duly sworn, did say that he is the President of Rock Road Industries, Inc., a Missouri corporation, and that said instrument was signed on behalf of said corporation by authority of its Board of Directors, and said person acknowledged said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal in the County and State aforesaid, the day and year first above written.

Margaret G. Cusumano
Notary Public

My Commission Expires:

November 5, 1998

MARGARET G CUSUMANO
NOTARY PUBLIC STATE OF MISSOURI
ST. LOUIS COUNTY
MY COMMISSION EXP. NOV. 5,1998

EXHIBIT "A"

AREA 1

A tract of land in part of U.S. Survey 131, Township 47 North, Range 5 East of the 5th Principal Meridian, St. Louis County, Missouri, described as follows:

Commencing at the intersection of the northwesterly line, of U.S. Survey 131 and the southwesterly right of way line of Highway 40, also known as St. Charles Rock Road; thence South 43 degrees 53 minutes 31 seconds East, along said right of way line, a distance of 729.68 feet; thence South 40 degrees 49 minutes 32 seconds West, a distance of 92.54 feet to the Point of Beginning of the following described tract; thence continuing South 40 degrees 49 minutes 32 seconds West, a distance of 288.61 feet; thence South 89 degrees 29 minutes 50 seconds West, a distance of 241.41 feet; thence North 79 degrees 05 minutes 44 seconds West, a distance of 390.43 feet; thence North 29 degrees 48 minutes 55 seconds East, a distance of 499.73 feet; thence North 84 degrees 45 minutes 59 seconds East, a distance of 248.68 feet; thence South 32 degrees 24 minutes 17 seconds East, a distance of 201.28 feet; thence South 56 degrees 18 minutes 22 seconds East, a distance of 251.78 feet to the Point of Beginning.

AREA 2

A tract of land in part of Lot 20, of the St. Charles Ferry Company Tract in U.S. Survey 47 and 1934 and in part of U.S. Survey 47 Township 47 North, Range 5 East of the 5th Principal Meridian, St. Louis County, Missouri, described as follows:

Commencing at the intersection of the centerline of St. Charles Rock Road and the northwesterly line of Lot 20 of the St. Charles Ferry Company Tract; thence North 28 degrees 53 minutes 11 seconds East, along said northwesterly line, a distance of 148.48 feet of the Point of Beginning of the following described tract; thence continuing North 28 degrees 53 minutes 11 seconds East, along said line, a distance of 676.08 feet to the northwest corner of said Lot 20; thence North 72 degrees 46 minutes 42 seconds West, along the northerly line of Lot 19 of the St. Charles Ferry Company tract, a distance of 674.79 feet; thence North 47 degrees 43 minutes 02 seconds East, a distance of 906.64 feet; thence South 64 degrees 46 minutes 52 seconds East, a distance of 389.58 feet; thence South 76 degrees 30 minutes 26 seconds East, a distance of 245.51 feet; thence South 60 degrees 07 minutes 01 seconds East, a distance of 283.36 feet; thence South 31 degrees 26 minutes 39 seconds West, a distance of 1136.42 feet; thence South 33 degrees 08 minutes 25 seconds West, a distance of 109.40 feet; thence South 34 degrees 54 minutes 38 seconds East, a distance of 149.81 feet; thence South 44 degrees 29 minutes 33 seconds West, a distance of 267.70 feet; thence North 78 degrees 25 minutes 41 seconds West, a distance of 241.02 feet; thence North 34 degrees 31 minutes 30 seconds West, a distance of 351.19 feet to the Point of Beginning.

[redacted]

199706300083 1

DANIEL T. O'LEARY
RECORDER OF DEEDS
ST. LOUIS COUNTY MISSOURI
41 SOUTH CENTRAL
CLAYTON, MO 63105

RECORDER OF DEEDS DOCUMENT IDENTIFICATION & CERTIFICATION SHEET

TYPE OF INSTRUMENT	GRANTOR	TO	GRANTEE
RESTR	LAIDLAW WASTE SYSTEMS BRIDGETON INC ETAL		

PROPERTY DESCRIPTION: YOSTI PARTITION LOT PT 1 2 & 3

Lien Number	Notation	Document Number	Locator
		831	

STATE OF MISSOURI)
SS.
COUNTY OF ST. LOUIS)

I, the undersigned Recorder of Deeds for said County and State, do hereby certify that the following and annexed instrument of writing, which consists of 10 pages, (this page inclusive), was filed for record in my office on the 30 day of June 1997 at 02:30 PM and is truly recorded in the book and at the page shown at the top and/or bottom of this page.

In witness whereof I have hereunto set my hand and official seal the day, month and year aforesaid.

SEAL OF THE RECORDER OF DEEDS FOR ST. LOUIS COUNTY, MO

Daniel T. O'Leary
Recorder of Deeds
St. Louis County, Missouri

J. Allen
Deputy Recorder

RECORDING FEE $42.32

(Paid at the time of Recording)

9

DECLARATION OF COVENANTS AND RESTRICTIONS

LAIDLAW WASTE SYSTEMS (BRIDGETON) INC.

Laidlaw Waste Systems (Bridgeton) Inc. f/k/a/ West Lake Landfill, Inc., a Missouri corporation ("Declarant"), hereby (a) imposes the provisions of this Declaration upon the Premises (as defined below), (b) publishes and declares that the following terms, conditions, restrictions and obligations shall (i) affect and encumber the Premises, (ii) run with and be a burden upon and a benefit to the Premises, and (iii) be fully binding upon Declarant and all persons or entities acquiring the Premises or any part thereof or interest therein whether by descent, devise, purchase or otherwise, and (c) declares that any person or entity, by the acceptance of title to the Premises or any part thereof or interest therein, shall thereby agree and covenant to abide by and be bound by the following terms, conditions, restrictions and obligations.

RECITALS

A. Declarant is the owner of certain real property (located in the City of Bridgeton, County of St. Louis, State of Missouri), legally described on Exhibit 1, attached hereto and incorporated herein by this reference, which real property is herein referred to as the "Premises".

B. The Premises and nearly all real property in the immediate vicinity of the Premises have been used exclusively for more than 40 years for non-residential uses, primarily for

commercial and industrial uses and in some cases, for agricultural uses.

C. Such uses have included, but have not been limited to, quarrying operations, demolition and sanitary landfill operations, asphalt and concrete batch plant operations, and vehicle maintenance, repair and body shop operations.

D. Such uses, and the character and nature of the land uses in the vicinity of the Premises, make the Premises unsuitable for any future residential use.

E. The United States Environmental Protection Agency ("EPA") has entered into an Administrative Order on Consent (the "Consent Order") with Cotter Corporation (N.S.L.), Declarant, Rock Road Industries, Inc., and the United States Department of Energy.

F. The Consent Order, among other things, (i) provides for the investigation of the nature and extent of contamination and any threat to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances at or from two isolated areas either on or in the vicinity of the Premises, which have been designated as Radiological Areas 1 and 2 in the Consent Order, and which contain low-level radioactive waste materials, and (ii) has been filed with the Regional Hearing Clerk, EPA, Region VII, 726 Minnesota Avenue, Kansas City, Kansas, Docket No. VII-93-F-0005.

G. The EPA and Declarant have entered into an additional Administrative Order on Consent, which has been filed with the Regional Hearing Clerk, EPA, Region VII, 726 Minnesota Avenue,

Kansas City, Kansas, Docket No. VII-94-F-0025, to investigate the nature and extent of any potential contamination at the Premises (other than Radiological Areas 1 and 2) relating to the historical use of the Premises.

H. Declarant desires to prohibit the present and future use of the Premises for any residential purpose in accordance with the terms and provisions of this Declaration.

DECLARATION

Declarant hereby states and declares as follows:

1. Neither the Premises, nor any portion thereof, shall be used now or hereafter for any residential purpose, or for any day care, preschool, or other educational use.

2. This Declaration shall not unlawfully restrict and shall not be used to violate any federal law, rule, or regulation regarding the use of real estate, including, but not limited to, the Fair Housing Act.

3. No water well for drinking water use shall be installed on the Premises.

4. This Declaration shall be recorded in the office of the Recorder of Deeds for the County of St. Louis, State of Missouri.

5. Any deed or other instrument of conveyance for the Premises or any portion therefor shall be subject to this Declaration.

6. Each of EPA (or its successor), the Missouri Department of Natural Resources ("MDNR") (or its successor), and the owner of any portion of the Premises shall have the right to sue for and

obtain an injunction, prohibitive or mandatory, to prevent the breach, or to enforce the observance, of this Declaration. This right shall be in addition to any other action available at law or in equity. The failure to enforce any covenant or restriction herein at the time of its violation shall not constitute a waiver of the right to do so later.

7. The provisions of this Declaration shall continue in full force and effect until the fiftieth anniversary of the date of this Declaration and thereafter for successive twenty-year periods unless, prior to the expiration of the then current term, a written notice of termination of this Declaration, executed by each of the then owners of the Premises and by authorized representatives of EPA (or its successor) and MDNR (or its successor), has been filed with the office of the Recorder of Deeds for St. Louis County, State of Missouri. A notice of termination of this Declaration may be filed at any time after the effective date of this Declaration, and the Declaration shall terminate on the date the notice of termination is filed with the Recorder of Deeds.

IN WITNESS WHEREOF, Laidlaw Waste Systems (Bridgeton) Inc. has caused this instrument to be executed this 9th day of June, 1997.

LAIDLAW WASTE SYSTEMS
(BRIDGETON) INC.

By _____

ACKNOWLEDGMENT

STATE OF Arizona)
) ss.
COUNTY OF Maricopa)

On this 9th day of June, 1997, before me, a notary public, personally appeared Steven Ekln, to me known, who, being by me duly sworn, did say that he is the Vice President of Laidlaw Waste Systems (Bridgeton) Inc., a Missouri corporation, and that said instrument was signed on behalf of said corporation by authority of its Board of Directors, and said person acknowledged said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal in the County and State aforesaid, the day and year first above written.

Mary Ulbrich Stoys
Notary Public

My commission expires:
5/16/99

EXHIBIT "1"

Landfill Area

Tract 1

A tract of land in part of Lots 1,2, and 3 of the Yosti Partition in U.S. Survey 131, part of Lots 20,21, and 22 of the St. Charles Ferry Company Tract in U.S. Survey 47 and 1934, part of U.S. Survey 131, and part of U.S. Survey 47 in Townships 46 and 47 North, Range 5 East of the 5th Principal Meridian, St. Louis County Missouri, described as follows:

Beginning at the intersection of the northwesterly line of U.S. Survey 131 and the southwesterly right of way line of Highway 40, also known as St. Charles Rock Road; thence South 43 degrees 53 minutes 31 seconds East, along said right of way line, a distance of 72.80 feet; thence South 51 degrees 12 minutes 40 seconds West, a distance of 277.46 feet; thence South 75 degrees 52 minutes 00 seconds West, a distance of 426.11 feet; thence North 50 degrees 18 minutes 12 seconds West, a distance of 205.86 feet; thence South 53 degrees 20 minutes 34 seconds West, a distance of 126.98 feet; thence South 39 degrees 22 minutes 26 seconds West, a distance of 463.83 feet; thence South 43 degrees 55 minutes 12 seconds East, a distance of 444.12 feet; thence South 2 degrees 03 minutes 23 seconds East, a distance of 332.12 feet; thence South 58 degrees 55 minutes 53 seconds West, a distance of 277.03 feet; thence around a curve to the left, having a radius of 450.00 feet and a chord bearing South 30 degrees 29 minutes 30 seconds West, a chord distance of 428.761 feet to a point of compound curve; thence around a curve to the left, having a radius of 150.00 feet and a chord bearing South 47 degrees 50 minutes 16 seconds East, a chord distance of 229.44 feet to its point of tangency; thence North 82 degrees 16 minutes 22 seconds East, a distance of 106.78 feet; thence South 7 degrees 43 minutes 38 seconds East, a distance of 65.61 feet; thence South 49 degrees 02 minutes 55 seconds East, a distance of 174.81 feet; thence South 56 degrees 34 minutes 13 seconds East, a distance of 296.04 feet; thence South 26 degrees 44 minutes 32 seconds West, a distance of 644.89 feet; thence South 51 degrees 56 minutes 32 seconds West, a distance of 311.60 feet to the centerline of St. Charles Rock Road; thence along said centerline the following courses and distances: North 61 degrees 07 minutes 11 seconds West, a distance of 739.36 feet; North 5 degrees 58 minutes 11 seconds West, a distance of 997.50 feet; North 11 degrees 22 minutes 11 seconds West, a distance of 477.70 feet; North 17 degrees 07 minutes 11 seconds West, a distance of 348.30 feet; North 31 degrees 34 minutes 11 seconds West, a distance of 349.50 feet; North 38 degrees 50 minutes 11 seconds West, a distance of 22.38 feet to the northwest line of Lot 20 of the St. Charles Ferry Company Tract; thence North 28 degrees 53 minutes 11 seconds East, along said Northwest line, a distance of 824.56 feet to the Northwest corner of said Lot 20; thence North 72 degrees 46 minutes 42 seconds West, along the North line of Lot 19 of the St. Charles Ferry Company Tract, a distance of 674.79 feet; thence North 47 degrees 43 minutes 02 seconds East, a distance of 1137.84 feet to the Southwesterly right of way line of Highway 40 also known as St. Charles Rock Road; thence along said right of way line the following courses and distances; thence South 75 degrees 56 minutes 31 seconds East, a distance of 260.00 feet; thence around a curve to the right, having a radius of 1825.08 feet and a chord bearing South 65 degrees 11 minutes 52 seconds East, a chord distance of 680.49 feet; thence

North 35 degrees 32 minutes 48 seconds East, a distance of 30.00 feet; thence around a curve to the right, having a radius of 1855.08 feet and a chord bearing South 49 degrees 10 minutes 22 seconds East, a chord distance of 341.47 feet; thence South 43 degrees 53 minutes 31 seconds East, a distance of 47.91 feet; thence South 46 degress 06 minutes 29 seconds West, a distance of 15.00 feet; thence South 43 degrees 53 minutes 31 seconds East, a distance of 34.28 feet; thence South 55 degrees 55 minutes 28 seconds East, a distance of 95.94 feet; thence South 43 degrees 53 minutes 31 seconds East, a distance of 602.78 feet to the Point of Beginning and containing 111.80 Acres.

Tract 2

A tract of land in part of Lots 1,3, and 4 of the Yosti Partition in U.S. Survey 131, and part of U.S. Survey 131, in Townships 46 and 47 North, Range 5 East of the 5th Principal Meridian, St. Louis County, Missouri, described as follows:

Beginning at the most easterly corner of Lot 1 of the Yosti Partition in U.S. Survey 131, being a point in the centerline of Taussig Avenue; thence South 43 degrees 34 minutes 53 seconds East, along the northeasterly line of Lot 4 of the Yosti Partition, a distance of 99.92 feet; thence South 6 degrees 41 minutes 15 seconds West, a distance of 68.96 feet; thence South 23 degrees 21 minutes 55 seconds West, a distance of 154.73 feet; thence South 26 degrees 49 minutes 07 seconds East, a distance of 55.27 feet; thence South 14 degrees 32 minutes 36 seconds West, a distance of 143.63 feet; thence South 34 degrees 03 minutes 12 seconds West, a distance of 220.86 feet; thence North 55 degrees 41 minutes 34 seconds West, a distance of 127.00 feet; thence South 88 degrees 59 minutes 19 seconds West, a distance of 62.24 feet; thence South 54 degrees 43 minutes 18 seconds West, a distance of 240.50 feet; thence South 26 degrees 44 minutes 32 seconds West, a distance of 450.91 feet; thence South 8 degrees 25 minutes 49 seconds West, a distance of 224.01 feet; thence South 17 degrees 14 minutes 43 seconds East, a distance of 28.63 feet; thence South 47 degrees 09 minutes 44 seconds East, a distance of 61.27 feet; thence South 24 degrees 34 minutes 10 seconds East, a distance of 73.64 feet; thence South 0 degrees 07 minutes 21 seconds West, a distance of 107.37 feet to the northeasterly right of way line of the St. Charles Rock Road, 60 foot wide; thence South 61 degrees 07 minutes 11 seconds East, along said right of way line, a distance of 758.45 feet to the most southerly corner of Lot 4 of said Yosti Partition; thence North 39 degrees 17 minutes 12 seconds East, along the southeasterly line of said Lot 4, a distance of 1349.58 feet to the most easterly corner thereof; thence North 43 degrees 34 minutes 53 seconds West, along the northeasterly line of said lot 4, a distance of 779.68 feet to a point 50.00 feet southeasterly of the most southerly corner of a tract of land conveyed to John Guerra and wife by deed recorded in Book 1642 on Page 263; thence North 46 degrees 24 minutes 31 seconds East, parallel with the southeasterly line of said Guerra tract, a distance of 437.11 feet; thence North 43 degrees 34 minutes 53 seconds West, parallel with the northeasterly line of said Guerra tract, a distance of 486.26 feet to the centerline of Taussig Avenue; thence North 41 degrees 52 minutes 29 seconds East, along said centerline, a distance of 68.21 feet; thence North 47 degrees 48 minutes 29 seconds East, along said centerline, a distance of 340.00 feet; thence North 42 degrees 11 minutes 31 seconds West, a distance of 30.00 feet to the northwesterly right of way line of said Taussig Avenue; thence North 47 degrees 48 minutes

29 seconds East, along said right of way a distance of 312.95 feet; thence North 5 degrees 09 minutes 06 seconds West, continuing along said right of way, a distance of 57.50 feet to the southwesterly right of way of Highway 40, also known as St. Charles Rock Road; thence North 43 degrees 53 minutes 31 seconds West, along said southwesterly right of way line, a distance of 877.45 feet; thence South 51 degrees 12 minutes 40 seconds West, a distance of 1023.23 feet; thence South 25 degrees 58 minutes 41 seconds West, a distance of 181.33 feet, to the northeasterly line of Lot 1 of the Yosti Partition of U.S. Survey 131; thence South 43 degrees 34 minutes 53 seconds East, along said northeasterly line, a distance of 971.20 feet to the Point of Beginning.

Tract 3

A tract of land being part of Lots 1, 3, and 4 of the "Yosti Partition in U.S. Survey 131, townships 46 and 47 north, range 5 east of the Fifth Principal Meridian, St. Louis County, Missouri, more particularly described as follows:

Commencing at the intersection of the northwesterly line of U.S. Survey 131 and the southwesterly right of way line of Highway 40, also known as "St. Charles Rock Road;" thence South 37 degrees 11 minutes 39 seconds East, along said south right of way line, 209.98 feet; thence exiting said right of way line, South 57 degrees 54 minutes 32 seconds West, 1023.23 feet; thence South 32 degrees 40 minutes 33 seconds West, 181.33 feet to the northeasterly line of said lot 1; thence South 36 degrees 53 minutes 01 seconds East, along said northeasterly line of lot 1, a distance of 591.05 feet to the point of beginning of the tract described herein; thence continuing along the northeasterly line of said lot 1 and along the northeasterly line of said lot 4, South 36 degrees 53 minutes 01 seconds East, 480.07 feet; thence exiting said northeasterly line, South 13 degrees 23 minutes 07 seconds West, 68.96 feet; thence South 30 degrees 03 minutes 47 seconds West, 154.73 feet; thence South 20 degrees 07 minutes 14 seconds East, 55.27 feet; thence South 21 degrees 14 minutes 28 seconds West, 143.63 feet; thence South 40 degrees 45 minutes 05 seconds West, 220.86 feet; thence North 48 degrees 59 minutes 42 seconds West, 127.00 feet; thence North 84 degrees 18 minutes 49 seconds West, 62.24 feet; thence South 61 degrees 25 minutes 10 seconds West, 240.50 feet; thence South 33 degrees 26 minutes 24 seconds West, 450.91 feet; thence South 15 degrees 07 minutes 41 seconds West, 224.01 feet; thence South 10 degrees 32 minutes 51 seconds East, 28.63 feet; thence South 40 degrees 27 minutes 52 seconds East, 61.27 feet; thence South 17 degrees 52 minutes 18 seconds East, 73.64 feet; thence South 06 degrees 49 minutes 13 seconds West, 107.37 feet to the north right of way line of "Old St. Charles Rock Road;" thence North 54 degrees 25 minutes 19 seconds West, along said right of way line, 99.72 feet; thence North 34 degrees 48 minutes 53 seconds East, 100.00 feet; thence exiting said west line, North 54 degrees 25 minutes 19 seconds West, 120.00 feet; thence North 21 degrees 27 minutes 09 seconds East, 153.52 feet; thence North 00 degrees 02 minutes 46 seconds West, 37.43 feet; thence North 56 degrees 33 minutes 36 seconds West, 70.00 feet; thence North 33 degrees 26 minutes 24 seconds East, 624.89 feet; thence South 49 degrees 52 minutes 21 seconds East, 56.85 feet; thence North 67 degrees 30 minutes 55 seconds East, 106.05 feet; thence North 08 degrees 48 minutes 44 seconds East, 158.15 feet; thence South 59 degrees 03 minutes 26 seconds East, 82.21 feet; thence North 33 degrees 28 minutes 55 seconds East, 321.44 feet; thence North 55 degrees 02 minutes 11 seconds West, 158.34 feet; thence North 01 degrees 10 minutes 17 seconds East, 342.38 feet to the point of beginning.

Excluding from the above tracts the real property sometimes referred to as Area 1 and Area 2, and more particularly described as follows:

AREA 1

A tract of land in part of U.S. Survey 131, Township 47 North, Range 5 East of the 5th Principal Meridian, St. Louis County, Missouri, described as follows:

Commencing at the intersection of the northwesterly line, of U.S. Survey 131 and the southwesterly right of way line of Highway 40, also known as St. Charles Rock Road; thence South 43 degrees 53 minutes 31 seconds East, along said right of way line, a distance of 729.68 feet; thence South 40 degrees 49 minutes 32 seconds West, a distance of 92.54 feet to the Point of Beginning of the following described tract; thence continuing South 40 degrees 49 minutes 32 seconds West, a distance of 288.61 feet; thence South 89 degrees 29 minutes 50 seconds West, a distance of 241.41 feet; thence North 79 degrees 05 minutes 44 seconds West, a distance of 390.43 feet; thence North 29 degrees 48 minutes 55 seconds East, a distance of 499.73 feet; thence North 84 degrees 45 minutes 59 seconds East, a distance of 248.68 feet; thence South 32 degrees 24 minutes 17 seconds East, a distance of 201.28 feet; thence South 56 degrees 18 minutes 22 seconds East, a distance of 251.78 feet to the Point of Beginning.

AREA 2

A tract of land in part of Lot 20, of the St. Charles Ferry Company Tract in U.S. Survey 47 and 1934 and in part of U.S. Survey 47 Township 47 North, Range 5 East of the 5th Principal Meridian, St. Louis County, Missouri, described as follows:

Commencing at the intersection of the centerline of St. Charles Rock Road and the northwesterly line of Lot 20 of the St. Charles Ferry Company Tract; thence North 28 degrees 53 minutes 11 seconds East, along said northwesterly line, a distance of 148.48 feet of the Point of Beginning of the following described tract; thence continuing North 28 degrees 53 minutes 11 seconds East, along said line, a distance of 676.08 feet to the northwest corner of said Lot 20; thence North 72 degrees 46 minutes 42 seconds West, along the northerly line of Lot 19 of the St. Charles Ferry Company tract, a distance of 674.79 feet; thence North 47 degrees 43 minutes 02 seconds East, a distance of 906.64 feet; thence South 64 degrees 46 minutes 52 seconds East, a distance of 389.58 feet; thence South 76 degrees 30 minutes 26 seconds East, a distance of 245.51 feet; thence South 60 degrees 07 minutes 01 seconds East, a distance of 283.36 feet; thence South 31 degrees 26 minutes 39 seconds West, a distance of 1136.42 feet; thence South 33 degrees 08 minutes 25 seconds West, a distance of 109.40 feet; thence South 34 degrees 54 minutes 38 seconds East, a distance of 149.81 feet; thence South 44 degrees 29 minutes 33 seconds West, a distance of 267.70 feet; thence North 78 degrees 25 minutes 41 seconds West, a distance of 241.02 feet; thence North 34 degrees 31 minutes 30 seconds West, a distance of 351.19 feet to the Point of Beginning.

THE STOLAR PARTNERSHIP
ATTORNEYS AT LAW
THE LAMMERT BUILDING
911 WASHINGTON AVENUE
ST. LOUIS, MISSOURI 63101-1290
(314) 231-2800

TELEFAX: (314) 436-8400

WILLIAM R. WERNER
Email: WRW@TSPSTL.COM

H.M. STOLAR
(RETIRED 1984)

February 5, 1998

David A. Hoefer, Esq.
Office of Regional Counsel
U.S. Environmental Protection
Agency - Region VII
726 Minnesota Ave.
Kansas City, KS 66101

RE: West Lake Landfill Site - Supplemental Declaration of Covenants and Restrictions

Dear David;

Attached for your file is a copy of the Supplemental Declaration of Covenants and Restrictions which was executed on behalf of Rock Road Industries, Inc. subsequent to your review. The Declaration has been recorded with the St. Louis County Recorder of Deeds at the Book and Page number shown on the enclosed copy.

Very truly yours,

William R. Werner

WRW:jvb
Enclosure
cc(w/enc): John Frazier
Angela Foster
Michael Hockley
Charlotte Neitzel
Paul Rosasco
James Wagoner II

BP11427/1655

[redacted]

199801200 1106

DANIEL T. O'LEARY
RECORDER OF DEEDS
ST. LOUIS COUNTY MISSOURI
41 SOUTH CENTRAL
CLAYTON, MO 63105

RECORDER OF DEEDS DOCUMENT IDENTIFICATION & CERTIFICATION SHEET

TYPE OF INSTRUMENT	GRANTOR	TO	GRANTEE
RESTR	ROCK ROAD INDUSTRIES INC		

PROPERTY DESCRIPTION: SUR 131 T 47 R 5 W/O/P

Lien Number	Notation	Document Number	Locator
		1,106	

STATE OF MISSOURI)
SS.
COUNTY OF ST. LOUIS)

I, the undersigned Recorder of Deeds for said County and State, do hereby certify that the following and annexed instrument of writing, which consists of 6 pages, (this page inclusive), was filed for record in my office on the 20 day of January 1998 at 04:27 PM and is truly recorded in the book and at the page shown at the top and/or bottom of this page.

In witness whereof I have hereunto set my hand and official seal the day, month and year aforesaid.

D. O'Leary

SUPPLEMENTAL DECLARATION OF COVENANTS AND RESTRICTIONS

ROCK ROAD INDUSTRIES, INC.

Rock Road Industries, Inc., a Missouri corporation ("Declarant"), hereby (a) imposes the provisions of this Supplemental Declaration upon the Premises (as defined below), (b) publishes and declares that the following terms, conditions, restrictions and obligations shall (i) affect and encumber the Premises, (ii) run with and be a burden upon and a benefit to the Premises, and (iii) be fully binding upon Declarant and all other persons or entities acquiring the Premises or any part thereof or interest therein whether by descent, devise, purchase or otherwise, and (c) declares that any person or entity, by the acceptance of title to the Premises or any part thereof or interest therein, shall thereby agree and covenant to abide by and be bound by the following terms, conditions, restrictions and obligations.

RECITALS

A. Declarant is the owner of certain real property (located in the City of Bridgeton, County of St. Louis, State of Missouri), legally described on Exhibit A, attached hereto and incorporated herein by this reference, which real property is herein referred to as the "Premises".

B. The United States Environmental Protection Agency ("EPA") has entered into an Administrative Order on Consent (the "Consent Order") with Cotter Corporation (N.S.L.), Declarant, Laidlaw Waste Systems (Bridgeton) Inc., and the United States Department of Energy for a Remedial Investigation and Feasibility Study.

C. The Consent Order, among other things, (i) provides for the investigation of the nature and extent of contamination and any threat to the public health, welfare, or the environment caused by the release or threatened release of hazardous substances at or from two

isolated areas either on or in the vicinity of the Premises and which have been designated as Radiological Areas 1 and 2 in the Consent Order, and which contain low-level radioactive waste materials (the "Environmental Condition"), and (ii) has been filed with the Regional Hearing Clerk, EPA, Region VII, 726 Minnesota Avenue, Kansas City, Kansas, Docket No. VII-93-F-0005.

D. The Premises is subject to a Declaration of Covenants and Restrictions dated May 27, 1997, which is recorded in Book 11208 Page 2507 in the St. Louis County Recorder of Deeds Office (the "May 1997 Declaration").

E. In addition to the restrictions contained in the May 1997 Declaration, Declarant desires to prohibit in perpetuity (i) the construction or placement upon the Premises of any building for any purpose, and (ii) the installation of underground utilities, pipes and/or excavation upon the Premises, except as set forth herein.

DECLARATION

Declarant hereby states and declares as follows:

1. No building of any kind or nature for any purpose shall be constructed or placed on the Premises, now or at any time in the future, in perpetuity. In addition, no underground utilities or pipes shall be installed at the Premises and no excavation work shall be performed on the Premises, now or at any time in the future, in perpetuity, except such utilities, pipes and/or excavation work, if any, which (a) are approved by EPA in connection with a plan selected by EPA to remediate the Environmental Condition and are performed in accordance with safety regulations applicable to such remedial plan or otherwise required by EPA as a condition of such approval, or (b) are any part of a landfill gas control, leachate collection, or surface water management system installed and operated pursuant to a plan approved by all

applicable Federal, State and/or local authorities exercising jurisdiction over inactive landfill conditions on the Premises or active or inactive landfill operations conducted adjacent to the Premises.

2. This Supplemental Declaration shall not unlawfully restrict and shall not be used to violate any Federal law, rule, or regulation regarding the use of real estate, including, but not limited to, the Fair Housing Act.

3. This Supplemental Declaration shall be recorded in the office of the Recorder of Deeds for the County of St. Louis, State of Missouri.

4. Any deed or other instrument of conveyance for the Premises or any portion thereof shall be subject to this Supplemental Declaration.

5. Each of EPA (or its successor), the Missouri Department of Natural Resources ("MDNR") (or its successor) and the owner of any portion of the Premises shall have the right to sue for and obtain an injunction, prohibitive or mandatory, to prevent the breach, or to enforce the observance, of this Supplemental Declaration. This right shall be in addition to any other action available at law or in equity. The failure to enforce any covenant or restriction herein at the time of its violation shall not constitute a waiver of the right to do so later.

6. The provisions of this Supplemental Declaration shall continue in full force and effect until the fiftieth anniversary of the date of this Supplemental Declaration and thereafter for successive twenty-year periods unless, prior to the expiration of the then current term, a written notice of termination of this Supplemental Declaration, executed by each of the then owners of the Premises and by authorized representatives of EPA (or its successor) and MDNR (or its successor), has been filed with the office of the Recorder of Deeds for St. Louis County, State of Missouri. A notice of termination of this Supplemental Declaration may be filed at any

time after the effective date of this Supplemental Declaration, and this Supplemental Declaration shall terminate on the date the notice of termination is filed with the Recorder of Deeds.

7. The May 1997 Declaration remains in full force and effect, and shall be deemed supplemented, but not amended, by this Supplemental Declaration.

IN WITNESS WHEREOF, Rock Road Industries, Inc. has caused this instrument to be executed this 16th day of January, 1998.

ROCK ROAD INDUSTRIES, INC., a Missouri corporation

By: _____
William E. Whitaker
President

ACKNOWLEDGEMENT

STATE OF MISSOURI)
) ss
County OF ST. LOUIS)

On this 16th day of January, 1998, before me, a notary public, personally appeared William E. Whitaker, to me known, who, being by me duly sworn, did say that he is the President of Rock Road Industries, Inc., a Missouri corporation, and that said instrument was signed on behalf of said corporation by authority of its Board of Directors, and said person acknowledged said instrument to be the free act and deed of said corporation.

IN WITNESS WHEREOF, I have hereunto set my hand and affixed my official seal in the County and State aforesaid, the day and year first above written.

Margaret G. Cusumano
Notary Public

My Commission Expires:

MARGARET G CUSUMANO
NOTARY PUBLIC STATE OF MISSOURI
ST. LOUIS COUNTY
MY COMMISSION EXP. NOV. 5,1998

EXHIBIT A

AREA 1

A tract of land in part of U.S. Survey 131, Township 47 North, Range 5 East of the 5th Principal Meridian, St. Louis County, Missouri, described as follows:

Commencing at the intersection of the northwesterly line of U.S. Survey 131 and the southwesterly right of way line of Highway 40, also known as St. Charles Rock Road; thence South 43 degrees 53 minutes 31 seconds East, along said right of way line, a distance of 729.68 feet; thence South 40 degrees 49 minutes 32 seconds West, a distance of 92.54 feet to the Point of Beginning of the following described tract; thence continuing South 40 degrees 49 minutes 32 seconds West, a distance of 288.61 feet; thence South 89 degrees 29 minutes 50 seconds West, a distance of 241.41 feet; thence North 79 degrees 05 minutes 44 seconds West, a distance of 390.43 feet; thence North 29 degrees 48 minutes 55 seconds East, a distance of 499.73 feet; thence North 84 degrees 45 minutes 59 seconds East, a distance of 248.68 feet; thence South 32 degrees 24 minutes 17 seconds East, a distance of 201.28 feet; thence South 56 degrees 18 minutes 22 seconds East, a distance of 251.78 feet to the Point of Beginning.

AREA 2

A tract of land in part of Lot 20, of the St. Charles Ferry Company Tract in U.S. Survey 47 and 1934 and in part of U.S. Survey 47 Township 47 North, Range 5 East of the 5th Principal Meridian, St. Louis County, Missouri, described as follows:

Commencing at the intersection of the centerline of St. Charles Rock Road and the northwesterly line of Lot 20 of the St. Charles Ferry Company Tract; thence North 28 degrees 53 minutes 11 seconds East, along said northwesterly line, a distance of 148.48 feet of the Point of Beginning of the following described tract; thence continuing North 28 degrees 53 minutes 11 seconds East, along said line, a distance of 676.08 feet to the northwest corner of said Lot 20; thence North 72 degrees 46 minutes 42 seconds West, along the northerly line of Lot 19 of the St. Charles Ferry Company tract, a distance of 674.79 feet; thence North 47 degrees 43 minutes 02 seconds East, a distance of 906.64 feet; thence South 64 degrees 46 minutes 52 seconds East, a distance of 389.58 feet; thence South 76 degrees 30 minutes 26 seconds East, a distance of 245.51 feet; thence South 60 degrees 07 minutes 01 seconds East, a distance of 283.36 feet; thence South 31 degrees 26 minutes 39 seconds West, a distance of 1136.42 feet; thence South 33 degrees 08 minutes 25 seconds West, a distance of 109.40 feet; thence South 34 degrees 54 minutes 38 seconds East, a distance of 149.81 feet; thence South 44 degrees 29 minutes 33 seconds West, a distance of 267.70 feet; thence North 78 degrees 25 minutes 41 seconds West, a distance of 241.02 feet; thence North 34 degrees 31 minutes 30 seconds West, a distance of 351.19 feet to the Point of Beginning.